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ABSTRACT

This bibliography includes 215 abstracts of publications on the use of nuclear energy in the production of potable water from saline or brackish waters. The uses of nuclear reactors, radioisotopic heat sources, and nuclear explosives are covered in relation to the various desalination methods available. Literature through April 1967 has been searched for the present edition. References to the technical report literature are arranged by report number under the issuing organizations, and the journal references are arranged alphabetically by journal title. Author and report number-availability indexes are included. (Author/PR)

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NUCLEAR ENERGY FOR WATER DESALTING

A BIBLIOGRAPHY

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SE 012 110

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UNITED STATES ATOMIC ENERGY COMMISSION
Division of Technical Information Extension

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ABSTRACT

This bibliography includes 215 references to publications on the use of nuclear energy in the production of potable water from saline or brackish waters. The uses of nuclear reactors, radioisotopic heat sources, and nuclear explosives are covered in relation to the various possible desalination methods available. Author and report number-availability indexes are included.

INTRODUCTION

Throughout the world there are at present serious shortages in the available fresh water supplies for basic human consumption, for industrial use, and for crop irrigation. The outlook for future fresh water needs indicates that critical shortages will develop in many areas of the world unless new methods of supply are found. One of the most promising methods currently under investigation is the desalination of sea and brackish waters. In this bibliography an attempt has been made to cite the report and published literature available on the use of nuclear energy for saline water demineralization. Some work has been done on the use of radioisotopic heat sources and the heat produced by a nuclear explosion, but the major emphasis of study to date has been on the development of large-scale nuclear reactors for use in dual-purpose power-water or water-only plants.

The present edition of NUCLEAR ENERGY FOR WATER DESALTING: A BIBLIOGRAPHY brings up to date the edition of September 1965 and its predecessor, originally issued for the Water Research Program at the Oak Ridge National Laboratory in July 1964 (ORNL-TM-892). Literature through April 1967 has been searched for the present edition.

References to the technical report literature are arranged by report number under the issuing organizations, and the journal references are arranged alphabetically by journal title.

REFERENCES

REPORTS

Allis-Chalmers Mfg. Co., Bethesda, Md., Atomic Energy Div.

1 (ACNP-65558(Rev. 1)) SURVEY OF HIGH-TEMPERATURE DEMINERALIZATION FOR DUAL-PURPOSE BWR PLANTS. Lang, Peter M. (Allis-Chalmers Mfg. Co., Atomic Energy Div., Bethesda, Md.). August 1965. 39p.

The removal of solids from the high temperature condensate returned from the brine heaters to the reactor in dual-purpose plants is examined in a study program on means of coping with brine-heater leakage. The results are presented of a search of the unclassified literature on the application of commercially available ion-exchange materials to the demineralization of high-temperature water. Operational data are given from two installations using ion-exchange demineralization under high-temperature conditions, and a survey is presented of specialty-type, leak-proof brine heaters and of systems for detecting brine-heater leakage and for isolating leaking units. A preliminary conceptual design of a mixed-bed ion-exchange unit is evolved for a dual-purpose boiling water reactor, and an operating cost comparison is made with the commercially available Powdex process. The operating cost of Powdex is estimated to be at least three times that of the unit used in the conceptual design.

2 (ACNP-65573) FLEXIBILITY STUDY OF BACK-PRESSURE TURBINES FOR DUAL-PURPOSE PLANTS. (Allis-Chalmers Mfg. Co., Bethesda, Md. Atomic Energy Div.). Aug. 1965. Contract W-7405-eng-26; Subcontract No. 2504. 48p. Dep. mn; CFSTI $2.00 cy, $0.50 mn.

For Oak Ridge National Lab., Tenn.

Back-pressure turbine-generator units rated at 500 Mw and exhausting at 35.4 psia (260°F) were studied for turbine throttle pressures of 600 psig and 1000 psig. For both throttle pressures, the turbine is a double flow, 1800 rpm, straight reaction machine. The steam cycle for the 600 psig throttle pressure uses a single open feedwater heater, and the cycle for the 1000 psig pressure uses an open heater plus a second closed heater. For each throttle pressure, plots are presented giving part-load and stretch-load performance for throttle flows up to the design value and for exhaust pressures from 15 psia to 80 psia. These plots show the electrical output, the heat exhausted to the water plant, and the temperature of the feedwater returned to the reactor. Other plots showing turbine expansion lines on Mollier diagrams, turbine heat rates, turbine exhaust enthalpies and flows, and gland-sealing steam requirements are also included. For operation at either increased or decreased exhaust pressure, certain turbine modifications are necessary, and the corresponding additional turbine costs were estimated. Similar differential costs to enable the generator to attain outputs in excess of 500 Mw are also given.

3 DUAL PURPOSE NUCLEAR PLANTS FOR WATER DESALINATION AND POWER. Lang, Peter M. (Allis-Chalmers Mfg. Co., Bethesda, Md.). 4p. (CONF-650429-11). ORINS.

From American Power Conference, Chicago.

With a nuclear dual purpose plant, operated at base load, the aim of obtaining desalted water from the ocean at costs within the 30-40¢/1000 gal. range while selling power at a normal price is attainable in the near future in those areas having large demands for both products. Converted water at this cost will replace few natural sources of water but will be acceptable for municipal and industrial uses where adequate natural sources do not exist. This cost of water is still too high for extensive agricultural use. The high present capital cost of water conversion plants is the main barrier to lowering the cost of desalted water. The aggressive development of water-conversion equipment now taking place should lead to future water costs significantly below those estimated here.

4 (ORNL-TM-1640) FLEXIBILITY OF A DUAL-PURPOSE PLANT TURBINE WITH LOWERED DESIGN EXHAUST PRESSURE. (Allis-Chalmers Mfg. Co., Bethesda, Md. Atomic Energy Div.). Jan. 1966. Contract W-7405-eng-26; Subcontract No. 2504. 30p. (ACNP-66508). Dep. mn. CFSTI $3.00 cy, $0.65 mn.

For Oak Ridge National Lab., Tenn.

Work to determine the improvement in performance and its accompanying increase in cost for a single turbine-generator unit rated at 500 MW when operating at 600 psig throttle pressure and 35.4 psia normal exhaust pressure, and having a design exhaust pressure of 20.0 psia is reported. In comparison with a previous 35.4 psia exhaust pressure turbine design, the 20.0 psia unit has one additional stage in each half of the double flow machine, an increase in the bearing center-line distance of 3 ft 6 in., and considerably altered blade designs, particularly toward the exhaust end. The steam cycle was retained unchanged from the previous study. Plots are presented giving the power output, the heat exhausted to the water plant, and the temperature of the feedwater returned to the reactor system as a function of exhaust pressure from 35.4 psia down to 7.0 psia and of throttle flow from approximately 25% of full flow up to full flow. Other plots showing turbine expansion lines on Mollier diagrams, turbine heat rates, turbine exhaust enthalpies and flows, and gland-sealing steam requirements are included. The extra cost of this turbine-generator in comparison to the previously studied 35.4 psia design exhaust pressure unit is given, as well as the additional cost for obtaining continuous safe full-flow operation of this unit at an exhaust pressure of 7.0 psia. Decreasing the design exhaust pressure of the turbine improves the flexibility of the turbine-generator plant without any reduction in performance at normal operating conditions.

American Machine and Foundry Co., Waterford, Conn.

5 SEAWATER CONVERSION USING A SMALL NUCLEAR HEAT SOURCE. Scanlan, T. R. (American Machine and Foundry Co., Waterford, Conn.), Schoenbrunn, A. G., and Minners, W. New York, American Society of Mechanical Engineers, 1964, Preprint No. 64-WA/NE-8, 7p, $1.00. (CONF-763-38).

From American Society of Mechanical Engineers Winter Meeting, New York, Nov.–Dec. 1964.

The investigation of a small nuclear heat source for use in operating a newly developed, multieffect, multistage (MEMS) flash-distillation plant is reported. The nuclear plant considered is of 21 megawatts thermal capacity. It is basically an upgraded research reactor using pressure-tube fuel elements containing UO_2 fuel. The new MEMS flash-distillation cycle operates at considerably higher efficiencies than present-day multistage flash-distillation plants.

Atomic Energy Board, Pelindaba, Pretoria (South Africa).

6 (PEL-97) NUCLEAR POWER ECONOMICS. A Bibliography Covering 1963–1965. Rossouw, S. F. (comp.) (Atomic Energy Board, Pelindaba (South Africa)). Jan. 1966. 118p. Dep. mn.

A bibliography containing 297 abstracts on the factors influencing the competitivity of nuclear reactors for electric power production is presented. A chapter is included on the economics for water desalination.

Atomic Energy Commission, Washington, D. C.

7 (A/CONF.28/P/220) NUCLEAR REACTORS APPLIED TO WATER DESALTING. Ramey, James T. (Atomic Energy Commission, Washington, D. C.); Carr, James K.; Ritzmann, Robert W. 16p.

Prepared for the United Nations Third International Conference on the Peaceful Uses of Atomic Energy, 1964.

The use of nuclear energy to desalt seawater is discussed. Water shortages in the United States and around the world are reviewed. The history of desalination activities is outlined. Results of studies of the use of heat from reactors for distillation are described. Economic aspects are discussed.

Atomic Energy of Canada, Ltd., Toronto (Ontario).

8 (AECL-2213) CANDU TYPE REACTORS FOR DUAL-PURPOSE POWER AND DESALINATION PLANTS. Wyatt, A. (Atomic Energy of Canada Ltd., Toronto, Ont.). Apr. 1965. 27p. Presented at the Canadian Nuclear Association International Conference and Exhibition, May 10–12, 1965, Quebec City, Quebec.

The economics of applying a CANDU type reactor to the particular circumstances of the joint US/Israel study of a dual purpose plant producing 200 MW(e) and 125 million gallons per day are considered. Since the economics are attractive relative to the use of boiling or pressurized water reactors, some consideration is given to the system planning aspects of dual purpose plants, with particular reference to flexibility of operation between the two portions of the overall plant. Brief summaries of the main desalination processes and of desalination costs are given in the appendices.

Atomic Energy Research Establishment, Harwell (England).

9 (AERE-M-1504) FRESH WATER FROM SEA-WATER—A SURVEY OF LARGE SCALE EVAPORATION PROCESSES Newson, I. H. (United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England). Dec. 1964. 25p. Dep.; $0.70(BIS); 3s.6d.(HMSO).

The efficiencies of modern large scale evaporation plants are discussed together with their technical limitations, problems, and costs. The most urgent research problems in this field lie in the prevention of scale deposition at temperatures above 250°F and in improving heat transfer and boiling under conditions of small temperature differences.

10 OBJECTIVES OF THE UNITED KINGDOM RESEARCH AND DEVELOPMENT PROGRAM FOR DESALINATION. Kronberger, H. (United Kingdom Atomic Energy Authority, Harwell, Eng.). 3p. (CONF-651005-2). ORAU. Gmelin, AED-CONF-65-276-4.

From 1st International Symposium on Water Desalination, Washington, D. C.

The present and immediately planned efforts of the U.K.A.E.A. in cooperation with industry in the desalination of water are briefly summarized. Various aspects of the multistage flash distillation process as well as related or supporting fundamental research studies currently underway are discussed. Designs of large combined desalination and nuclear power plants now being prepared are mentioned. Although the main effort is being devoted to the work on flash distillation, some alternative methods that are being studied are summarized.

Atomic Industrial Forum, Inc., New York.

11 PROCEEDINGS OF THE 1965 CONFERENCE, ATOMIC INDUSTRIAL FORUM, INC., WASHINGTON, D. C. McCluskey, Robert J. (ed.). Atomforum/65. New York, Atomic Industrial Forum, 1966. 280p. $15.00. (CONF-651132).

The development of nuclear energy is discussed with emphasis on the areas of marine applications of nuclear energy, economics of nuclear fuels, international development programs, industrial aspects of international safeguards, saline water conversion, space applications, and non-power applications of isotopes and radiation.

Atomics International, Canoga Park, Calif.

12 APPLICATION OF NUCLEAR ENERGY TO LARGE-SCALE POWER AND DESALTING PLANTS. Siegel, Sidney; Golan, Simcha; Falcon, Joseph A. (Atomics International, Canoga Park, Calif.). 24p. (CONF-650429-9).

From American Power Conference, Chicago.

Specific types of nuclear power plants in combination with desalting plants are examined to establish the relative economic potential of various heat sources for large-scale dual-purpose application. It was concluded that both technically and economically the dual-purpose approach has a decided advantage where a ready market exists for the power produced.

Australian Atomic Energy Commission.

13 (NP-16359) FOURTEENTH ANNUAL REPORT FOR THE YEAR ENDED 30TH JUNE, 1966. (Australian Atomic Energy Commission). 104p. Dep. mn.

Developments in research carried out by the AAEC on nuclear power, peaceful uses of nuclear explosives, nuclear desalination, raw materials, and radioisotopes are reported.

Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.

14 (BNWL-SA-134) DESALINATION OF SEA-WATER. Harty, H. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Apr. 12, 1965. Contract AT-(45-1)-1830. 32p. (CONF-650432-1). Dep.(mn); $2.00 (cy), 1(mn) CFSTI.

From 53rd General Conference of Pacific-Northwest Trade Association, Portland, Ore.

After a brief survey of water resources and usage in the U. S., the means for meeting water shortages are considered: water reuse, storage, redistribution, and desalination of sea or brackish waters. The factors that will decide which of these methods will be used in a locality are discussed: water quality requirements, status of desalination technology, and water cost considerations. Seawater desalination is presently not widely competitive with other processes, but factors which may change this situation are discussed.

15 (BNWL-SA-596) ENVIRONMENTAL FACTORS RELATING TO LARGE WATER PLANTS. Parker, Her-

bert M. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Mar. 15, 1966. Contract AT(45-1)-1830. 29p. (CONF-660311-1). Dep. mn. CFSTI $2.00 cy, $0.50 mn.

From Symposium on Water Production Using Nuclear Energy, Tucson, Ariz.

A review of work done in marine biology, fisheries and environmental science, aquatic biology, environmental science, and nuclear and desalination engineering in connection with water production plants is presented.

Bechtel Corp., San Francisco, Calif.

16 LARGE-SCALE NUCLEAR DESALTING PLANTS. Galstaun, Lionel S. (Bechtel Corp., San Francisco). 12p. (CONF-651132-6). ORAU. Gmelin, AED-CONF-65-337-3.

From Atomic Industrial Forum, 12th Annual Conference, Washington, D. C.

A comparison is made of the costs of desalting water in 150 million gallon per day multistage desalting plants. Both dual purpose nuclear power-water and water-only plants are considered. The basis for the dual purpose units has been the commercially available light water reactors, whereas the single purpose unit used the Deep Pool Reactor Concept. All estimates of cost, including capital, fixed annual operating costs, and fuel cycle costs were related to the basis used in the report for the Metropolitan Water District of Southern California. The results show that the costs in every case are lower when electricity and power are produced. One major reason is the higher cost for energy in the single purpose plant.

17 WATER-ONLY PLANT STUDIES. Clark, Richard L. (Bechtel Corp., San Francisco). 18p. (CONF-660311-5). ORAU. Gmelin, AED-CONF-66-037-9.

From Symposium on Water Production Using Nuclear Energy, Tucson, Ariz.

Recent water desalting plant design studies are analyzed and a comparison is made of the cost of water from dual-purpose and water-only plants. The factors affecting the decision to build a water-only or a dual-purpose plant are discussed. Two approaches to reducing the cost of desalted water from water-only plants are compared. One approach is based on high temperature multistage flash evaporation while the other approach incorporates the low temperature Deep Pool Reactor concept. It is concluded that the cost of water is higher from a water-only desalting plant but a particular combination of conditions is necessary to justify a dual-purpose installation. Future process development may diminish the cost difference between dual-purpose and water-only operation.

18 DUAL-PURPOSE NUCLEAR POWER AND DESALTING PLANTS. Wilson, William H. (Bechtel Corp., San Francisco). 16p. (CONF-660325-1). ORAU. Gmelin, AED-CONF-66-040-2.

From Pacific Coast Electrical Assn., Annual Conference, Engineering and Operating Section, San Francisco.

An engineering and economic feasibility study of a dual-purpose nuclear plant producing 150 to 750 MW(e) and 150 mgd of desalted water for Southern California is described. The site selection, man-made island design, comparison of fossil- and nuclear-fueled plants, power plant size selection, desalting process selection, combined plant concept, plant capital costs, and desalted water costs are summarized.

19 STUDY OF 150 MGD DESALTED WATER-POWER DUAL PLANT FOR SOUTHERN CALIFORNIA. Currier, Edwin L. (Bechtel Corp., San Francisco); Holtom, H. T. 22p. (CONF-660546-1). ORAU. Gmelin, AED-CONF-66-111-2.

From American Society of Civil Engineers, Water Resources Engineering Conference, Denver, Colo.

The findings of a study on the engineering and economic feasibility of a 150 million gallon per day dual-purpose desalination plant for Southern California are presented. The power plant size, the cases studied, the conceptual plant description, site selection, and cost are discussed. An optimum plant design employs either a boiling or pressurized light water reactor producing 1,629 MW(e) and furnishing steam to a 150 mgd multistage flash evaporator plant.

20 ELECTRICAL ASPECTS OF A LARGE DUAL-PURPOSE NUCLEAR POWER AND DESALTING PLANT. Zweigler, R. (Bechtel Corp., Los Angeles). New York, Inst. of Electrical and Electronics Engineers, 1966, Paper No. 31PP66-523, 27p. (CONF-660708-8). ORAU.

From IEEE Summer Power Meeting, New Orleans.

The electric power system engineering considerations involved in developing a 1790 MW(e) nuclear-generating and 150 mgd seawater desalting plant in Southern California are discussed. The plant process, siting, and power and water production and costs are examined for a man-made island off the coast. Auxiliary power systems for the power and desalting plant and product water pumping are considered, and electric power transmission methods from the island are evaluated.

21 (COO-283) DEEP-POOL REACTOR FOR WATER DESALTING. (Bechtel Corp., San Francisco, Calif.). June 30, 1965. 138p. $5.00(CFSTI).

The technical features and the economics of a particular reactor concept offering the potential of low capital and energy costs for use in a single-purpose water desalting plant were determined. In order to evaluate the economics of the system, the deep-pool reactor heat source was assumed to supply heat to a multistage flash evaporation water desalting plant. The emphasis of the study was on the reactor heat source. The design and cost estimate of the water plant itself was based on previous studies and on a computer code for optimization of multistage flash evaporation plants. The components of the water plant were identified only to the extent necessary to be compatible with the unique features of the deep-pool reactor. The reference case is a 50-million gallon per day (mgd) plant. The plant description and detailed cost estimate refer specifically to this case. Adjustments were made to plants of 10-mgd and 200-mgd capacity to provide an indication of the effect of size on the cost of the water produced. Special consideration was given to the unique aspects of the reactor plant design, including material compatibility and the design requirements associated with the depth of the reactor tank. The safety advantages inherent in the essentially unpressurized, deep-pool reactor concept were utilized in the plant design and were evaluated in a preliminary accident analysis. Siting studies were made to define the site conditions to be assumed and the plant design features required for the hypothetical southern California coastal site assumed as a basis of the study. Auxiliary systems comparable to those in existing water reactor power plants were defined.

22 (TID-19267) LARGE REACTOR STUDY FOR SEAWATER DISTILLATION. Final Report. (Bechtel Corp., San Francisco). July 1963. Includes Appendices A through F. Contract AT(04-3)-507. 271p.

The results of a study of large nuclear reactor systems for supplying energy for the distillation of seawater are presented. The reactor types and sizes studied include: one 1500-MW(t) light-water reactor of current technology; three 1500-MW(t) light-water reactors in a single plant; one 3220-MW(t) light-water reactor; one 3500-MW(t) heavy-water-moderated, organic-cooled reactor; one 3500-MW(t) graphite-moderated, light-water-cooled reactor; one 8300-MW(t) heavy-water-moderated, organic-cooled reactor; a multiunit 25000-MW(t) station with high conversion ratio reactors; a 25000-MW(t) station using an unspecified number of slightly enriched reactors; and an unspecified number of fast breeder reactors of 25000-MW(t) total capacity. A summary of technical design data is presented. Costs for all cases were calculated and translated into annual costs.

23 (TID-22330(Vol.1)) ENGINEERING AND ECONOMIC FEASIBILITY STUDY FOR A COMBINATION NUCLEAR POWER-DESALTING PLANT. PHASES I AND II. (Bechtel Corp., San Francisco, Calif.). Dec. 1965. 509p. Dep. mn; CFSTI $4.00 cy, $2.25 mn.

The finding and conclusions of economic and engineering feasibility studies of a combination power and desalting

plant for operation in southern California are presented. Results of the study are given on the effect of blending at the Diemer plant, product conveyance and blending facilities, conceptual designs of seawater systems, nuclear site safety analysis, site selection, fossil versus nuclear fueled dual purpose plants, optimization of dual purpose plants, conceptual plant descriptions, plant capital cost estimates, and the cost of water.

24 (TID-22330(Vol.2)) ENGINEERING AND ECONOMIC FEASIBILITY STUDY FOR A COMBINATION NUCLEAR POWER AND DESALTING PLANT. PHASE III. (Bechtel Corp., San Francisco, Calif.). Dec. 1965. 599p. Dep. mn. CFSTI $4.00 cy, $2.75 mn.

A detailed analysis of the feasibility of dual-purpose plants located at Pelican Point and on Bolsa Island (a man-made island) and of the cost of water from these plants is summarized. Plants using boiling-water and pressurized-water reactors were considered. It is recommended that the Bolsa Island site be selected for the location of the plant.

25 (TID-22330(Vol.3)) ENGINEERING AND ECONOMIC FEASIBILITY STUDY FOR A COMBINATION NUCLEAR POWER AND DESALTING PLANT. SUMMARY. (Bechtel Corp., San Francisco, Calif.). Dec. 1965. 199p. Dep. mn. CFSTI $1.25 cy, $1.25 mn.

The economics, plant analysis, siting analysis, and feasibility of a combination nuclear-desalting and power-producing plant on the California coast are reviewed and evaluated.

Brookhaven National Lab., Upton, N. Y.

26 (BNL-959) THE IMPACT OF INTEGRATED MULTIPURPOSE NUCLEAR PLANTS ON THE CHEMICAL AND METALLURGICAL PROCESS INDUSTRIES. I. ELECTROCHEMONUCLEAR SYSTEMS. Steinberg, Meyer (Brookhaven National Lab., Upton, N. Y.). Dec. 1964. Contract AT(30-2)-Gen-16. 29p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

The recent development of large-scale nuclear sources of low cost electrical power makes it possible to consider the coupling of nuclear power reactors with efficient electrochemical devices for large-scale production of industrial chemicals. The electrochemonuclear system consists of the three basic building blocks: nuclear reactor, d-c generator, and electrochemical cell. The electrochemonuclear generation of H_2 and O_2 is of interest for the fixation of N for fertilizers, generation of liquid and gaseous carbonaceous fuels, the production of Fe and steel, and the production of liquid H_2 and O_2 for aircraft and rocket fuel. Based on the speculation that low cost, high pressure water electrolyzers can be developed, estimates of the economics of electrochemonuclear ammonia production relative to conventional fossil-fuel-based plants are presented as a function of nuclear power costs. A desalinated water and fertilizer electrochemonuclear plant appears attractive. A dual-cycle, high temperature radiation and electrochemonuclear reactor offers a highly efficient N fixation system in the future. The realization of these concepts depends on a combination of low cost nuclear power, low investment electrochemical devices, and utilization of by-products.

Burns and Roe, Inc., New York.

27 STRUCTURAL ENGINEERING ASPECTS OF A DUAL-PURPOSE DESALTING AND NUCLEAR POWER PLANT. Perri, Joseph G. (Burns and Roe, Inc., New York). 33p. (CONF-660112-1). ORAU. Gmelin, AED-CONF-66-007-1.

From American Society of Civil Engineers, Structural Engineering Conference, Miami Beach, Fla.

A conceptual presentation is made of a dual-purpose desalination and nuclear power plant, with the ultimate objective of bringing forward the structural engineering aspects of a modular vessel-structure assembly that, by its unusual features, illustrates effectively the great new developments associated with saline-water conversion. The material selected for this presentation embraces concepts and ideas representing the outcome of many months of fruitful researches on the subject of Controlled Flash Evaporators. One special concept for the Structure, the peculiarly shaped module which consists of an orthotropic plate system, is believed to be the appropriate selection for effectively conveying the idea of what can be accomplished with a traditional material conventionally limited to some specific engineering aspects. The modular concept as applied to boiler segments of limited magnitude and with pressurized elements independently and internally built is not new; its application, however, to evaporator stages of great magnitude is certainly an evolutionary product of the present engineering designs. This new application of the module will be of interest both to the engineers engaged in researches in the field of industrial design and the engineers dedicated to analogous structural configurations. Although no general theoretical derivations are given of the complete mathematical treatment of orthotropic plates, some general transformations of the constant coefficients of either the fourth or eighth order differential equations are given and adequate emphasis on fundamental principles associated with the use of the coefficients in the equations for pressurized orthotropic systems are discussed. In this respect, it is believed that the idea of a fictitious plate constitutes a contribution to the analysis of orthotropic plates.

28 (NYO-10719) FEASIBILITY STUDY OF A DUAL-PURPOSE NUCLEAR REACTOR POWER PLANT FOR THE FLORIDA KEYS. (Burns and Roe, Inc., New York). Mar. 1964. Contract AT(30-1)-3277. 206p.

The application of nuclear energy to the desalination of water is an area where there is much promise for a near-term economically competitive situation with fossil-fueled heat sources. Nuclear reactors can be used in one of two ways to produce the process steam needed for desalting seawater. The possibilities are: (1) design a reactor with minimum capital and fuel costs to produce low-pressure steam exclusively and directly; or (2) design a reactor system that will produce electricity by a turbine generator, either backpressure or extraction, and use the backpressure or extraction steam as the heat source for the water desalination plant. This investigation concentrated on the second possibility because the first approach would have no economic advantage over a fossil-fuel-fired single-purpose water plant in the applicable water capacity ranges. Based on steam and electrical requirements determined from studies of combined desalination and power plant installations in the Florida Keys conducted for the OSW under a parallel contract, it was established that reactor power levels in the range 120 to 220 MW(t) would be required. To obtain valid information for comparison of boiling- and pressurized-water reactor systems in the selected size range, proposals were requested and received from five reactor manufacturers. Two of these proposals were based on the boiling-water concept and the remaining three utilized pressurized-water reactor designs. All of the proposals were evaluated on a uniform basis, insofar as practicable. Where such items as auxiliary systems or steam generators for brine steam (in the case of the boiling-water designs) were not included in the quoted costs, adjustments were made accordingly. This brought each bid to the same degree of completeness and thus normalized the overall installed costs. Features considered, in addition to costs, were reliability, proven design, operability and maintainability, efficiency and safety, and vendor experience. From a comparison of all the factors considered it was concluded that the proposals from Vendor A met the design requirements and were best suited economically for furnishing electricity and steam, in a dual-purpose combined power and water desalination plant. To verify quoted figures, detailed fuel cost calculations were made and compared with the figures given by Vendor A. Fair agreement was found; the costs were 24.3 cents/million Btu as compared to the Vendor A estimate of 21 cents/million Btu. Among the factors that account for the differences are the allowances for fuel processing, the estimated batch size charged to the reactor per refueling operation, and the daily separation plant charges. Since the fuel cycle data submitted by Vendor A are estimates (and most likely conservative) for proposal purposes, a more detailed and precise determination of

differences would not be warranted for this study. However, to ensure adequate margins in calculating nuclear power costs, nuclear fuel costs of 24.3 cents/million Btu were used. Using the Vendor A designs producing 412 and 700 psia steam, preliminary studies were made of the steam costs to a desalination plant producing 6,000,000 gallons per day of fresh water, which was the basis used prior to the final selection of the water plant capacity. These initial calculations showed that the 700 psia steam reactor design gave the lower power costs of the two pressures offered. Further, the incremental increase in power costs resulting from a power plant designed to meet combined needs, as compared to an unassociated power plant, were smaller for the nuclear system than for a fossil-fueled plant. It was found, after developing costs for brine heater steam extracted at pressures of 37.9, 49, and 67 psia, that the lowest-pressure steam had the least cost. While the initial studies were based on a water plant capacity of 6,000,000 gallons per day, detailed present worth analyses of six water supply patterns, performed for the Office of Saline Water, showed that 10,000,000 gallons per day of fresh-water production was the optimum plant capacity. Similarly, it was determined that a single power plant, rated at a net output of 50 MW(e) and designed to furnish electricity to both the Upper and Lower Keys, was the most economical unit to install initially. Studies of site characteristics showed that Sugarloaf Key was best suited for the installation of the nuclear dual-purpose facility. The results of the calculations for the recommended combined plants are summarized, with the fossil-fueled units included for comparison. Steam costs from the nuclear plant were found to be lower than the corresponding costs from fossil plant. This situation, which is unusual for nuclear plants of comparatively low outputs, is largely due to four factors: (a) The compact Vendor A primary system design combined with the pressure suppression containment building arrangement results in a nuclear plant of low first cost. (b) Use of municipal financing with its lower fixed charge rate than industrial financing decreases the disadvantage of the higher nuclear plant first cost compared to fossil-fuel plants. (c) The nuclear fuel costs for the selected reactor design are comparatively low at 24.3¢/10^6 Btu. (d) The fuel oil cost of 42¢/10^6 Btu at the Florida Keys is relatively high. The analyses of electric power costs are based on normal economics, i.e., no subsidies or monies for research and development assistance or for design support were assumed for the nuclear reactor system. Further, fuel costs include fuel use charges as well as all other factors. For the nuclear reactor systems the fixed charge items were based on municipal financing and were established as 7.30 percent per year for depreciating capital and 5.17 percent per year for nondepreciating capital. For fossil-fuel plants the insurance allowance was reduced to 0.35 percent, thus yielding 7.15 percent and 5.02 percent for depreciating and nondepreciating capital respectively. The results of this study indicate an economic advantage for a dual-purpose nuclear power and water desalination plant, as compared to a fossil-fuel-fired unit with similar capacities and functions. Because of the economic savings shown, and the anticipated advancements in the state-of-the-art attendant to the application of combined nuclear power and large-scale water desalination, the reactor system described is recommended as the basis for detailed engineering designs of dual-purpose plants in the Florida Keys.

29 (PB-181694) PARAMETRIC COST STUDIES PERTAINING TO DUAL-PURPOSE POWER AND WATER DESALINATION PLANTS. Research and Development Progress Report No. 109. Stone, L.; Patti, F. J.; Knebel, M. E.; Gerber, W. G.; Zizza, M.; Baron, S. (Burns and Roe, Inc., New York). (1963). 103p. $2.75(CFSTI).

Three related studies are carried out: determination of the design and costs of dual-purpose seawater desalination-electricity nuclear power plants with outputs of 7 to 50 MGD; minimum costs of desalination without power production in 40-MWt nuclear reactors; and minimum costs of desalination without power production in conventional plants having outputs of 1 to 14 MGD. Multistage flash evaporation is the desalination mechanism used in each case, and the desalination is carried out to the level at which the water is potable.

California Univ., Livermore. Lawrence Radiation Lab.

30 (UCRL-5678) HEAT REQUIREMENTS FOR THE HIGH PRESSURE DISTILLATION OF SEAWATER. Olson, Raymond L. (California. Univ., Livermore. Lawrence Radiation Lab.). p.8–12 of PROCEEDINGS OF THE SECOND PLOWSHARE SYMPOSIUM. PART IV. INDUSTRIAL USES OF NUCLEAR EXPLOSIVES IN THE FIELDS OF WATER RESOURCES, MINING, CHEMICAL PRODUCTION, PETROLEUM RECOVERY. Plowshare Series: Report No. 2. (California. Univ., Livermore. Lawrence Radiation Lab. and San Francisco Operations Office, AEC). May 15, 1959. 102p. OTS.

In a proposed method for the high pressure distillation of seawater the distillation would take place in a deep underground cavity formed by the explosion of a nuclear device. The high pressure in the cavity would be maintained by the hydrostatic heads of seawater and distilled water in the piping above the cavity. A depth of over 5,000 feet has been suggested. The heat of distillation would come from the heat of the nuclear explosion stored in the material surrounding the cavity; the separated salt would be left in the cavity. By transferring heat from the outgoing distilled water to the incoming seawater, the amount of heat necessary for the distillation can be minimized. The thermal efficiency of the process and heat requirements for the distillation are discussed. Preliminary cost estimates for the process are included.

31 (UCRL-6588) WATER CONSERVATION WITH NUCLEAR EXPLOSIVES. Higgins, Gary (California. Univ., Livermore. Lawrence Radiation Lab.). Aug. 29, 1961. Contract W-7405-eng-48. 12p.

From Water for Texas Conference, College Station, Texas, Sept. 1961.

Application of nuclear explosives to water resource conservation has been one of the areas of study included in the Plowshare Program since its inception. Several possibilities, including creation of inexpensive water diversion canals, large permeable zones for waste or brine disposal or for underground recharge, and construction of surface storage basins, continue to appear attractive. Creation of new underground storage volume and salt water conversion seem, on the basis of available information, less likely to be successful. Production of earth dams by explosive emplacement is being considered. In all of these studies, which make use of data obtained from past nuclear tests, evaluation of safety problems constitutes a major effort. In many cases there is presently insufficient information to make firm conclusions, while in a few there appear to be no insurmountable safety problems. If results of studies continue to be encouraging, nuclear explosives may make possible projects which have hitherto been too large or costly to consider. These applications may be possible within the next decade or two.

California Univ., Los Angeles. Dept. of Engineering.

32 SALINE WATER CONVERSION—A REVIEW AND BIBLIOGRAPHY. McCutchan, J. W. California. Univ., Los Angeles, Dept. of Engineering. Rept. No. 61-61. 94p. Sept. 1961.

A general review is presented of the potentially feasible processes of saline water conversion, including distillation, processes using membranes, freezing, and chemical, electrical, and biological processes. The utilization of calcined radioactive wastes as a heat source for desalination processes is discussed briefly. A large bibliography is included.

California Univ., Los Angeles. Inst. of Geophysics.

33 (UCRL-5678) SALT WATER DISTILLATION. Kennedy, George C. (California. Univ., Los Angeles.

Inst. of Geophysics). p. 4–7 of PROCEEDINGS OF THE SECOND PLOWSHARE SYMPOSIUM. PART IV. INDUSTRIAL USES OF NUCLEAR EXPLOSIVES IN THE FIELDS OF WATER RESOURCES, MINING, CHEMICAL PRODUCTION, PETROLEUM RECOVERY. Plowshare Series: Report No. 2. (California. Univ., Livermore. Lawrence Radiation Lab. and San Francisco Operations Office, AEC). May 15, 1959. 102p. OTS.

The utilization of the heat produced in an underground nuclear explosion for the distillation of seawater to produce fresh water is discussed. It is stated that the process appears to be possible and economical. The fundamental principles of distillation are reviewed and a phase equilibrium diagram of the sodium chloride-water system is presented.

Canadian General Electric Co., Ltd., Peterborough (Ontario). Civilian Atomic Power Dept.

34 (NP-15920) A PRELIMINARY REPORT ON AN HWR PLANT FOR ELECTRIC POWER AND WATER DESALINATION. (Canadian General Electric Co. Ltd., Peterborough (Ontario). Civilian Atomic Power Dept.). Sept. 1963. 13p. Dep. mn.

The Canadian HWR was investigated for use as a dual-purpose reactor. Economics are discussed.

35 SOME CONSIDERATIONS ON UTILIZING A CANADIAN HEAVY-WATER REACTOR IN A DUAL-PURPOSE POWER-DESALINATION PLANT. Williams, N. L. (Civilian Atomic Power Dept., Canadian General Electric Co. Ltd., Peterborough, Ont.). pp 91–101 of STI-DOC-10/51.

An analysis was made of a Canadian heavy water reactor for the purpose of evaluating its performance for electric power generation and seawater desalination. Results are discussed.

Catalytic Construction Co., Philadelphia, Pa. and Nuclear Utility Services, Inc., Washington, D. C.

36 (NYO-3316-1) A STUDY OF DESALTING PLANTS (15 TO 150 mgd) AND NUCLEAR POWER PLANTS (200 TO 1500 MWt) FOR COMBINED WATER AND POWER PRODUCTION. Final Report. (Catalytic Construction Co., Co., Philadelphia and Nuclear Utility Services, Inc., Washington, D. C.). Sept. 1964. Contracts AT(30-1)-3316 and 14-01-0001-367. 358p. Dep.; $3.50(OTS).

An analysis is carried out of the various factors affecting the economics of seawater desalination by a multistage flash-evaporation plant, operated in conjunction with an electricity-generating station. Four concepts are considered as power sources for the combined facility, namely, low- and high-temperature nuclear reactors and low- and high-temperature natural-gas boilers. Plant sizes of 200 to 1500 MWt are considered. The economics of the station are compared with the economics of separately operated plants of the same water and electric outputs.

Chance Vought Corp., Dallas, Tex.

37 (AER-E1R-13574) PROJECT ARTESIA FINAL REPORT. VOL. I. ECONOMIC FEASIBILITY. Welt, M. A.; Armstrong, G. R.; McWhorter, C. R. (Chance Vought Corp., Aeronautics Div., Dallas, Tex.). Sept. 1961. 120p.

The use of radioisotopic power is considered as a heat source for saline water conversion. The most economical source appears to be the calcined fission product waste from processed spent reactor fuel elements. The results indicate that, for special conditions, this source of heat is competitive with conventional fuels.

38 (AER-E1R-13575) PROJECT ARTESIA FINAL REPORT. VOL. II. TECHNICAL FEASIBILITY. Welt, M. A.; Armstrong, G. R.; Boruff, W. R.; Coleman, R. R. (Chance Vought Corp., Aeronautics Div., Dallas, Tex.). Sept. 1961. 179p.

The results of various studies on compatibility, thermodynamics, nuclear, and material aspects of a full scale heater utilizing calcined radioisotope waste products (ARTESIA) are presented. These studies have permitted the conceptual design of an ARTESIA heater capable of supplying the thermal requirements for a 1 million gallon per day saline water conversion system operating at 200 kwh/1000 gal. Based on these data, a laboratory test model (Volume III) will be designed and fabricated to investigate, by test, problems which may be expected with the full scale design.

39 (AER-E1R-13576) PROJECT ARTESIA FINAL REPORT. VOL. III. EXPERIMENTAL TEST MODEL DESIGN. Welt, M. A.; Armstrong, G. R.; Boruff, W. R.; Charak, I.; Coleman, R. R. (Chance Vought Corp., Aeronautics Div., Dallas, Tex.). September 1961. 179p.

ARTESIA proposes the use of radioisotopes as an energy source for saline water conversion. The economic and technical feasibility has been analytically established. Further work is included on the design of an experimental test model capable of producing 250 gallons per day using one megacurie of cerium 144 and a six-stage flash evaporation conversion unit. Also included is a hazards analysis of the test model.

40 (PB-181469) UTILIZATION OF ISOTOPES FOR SALINE WATER CONVERSION. Research and Development Progress Report No. 68. (Chance Vought Corp., Dallas). Dec. 1962. 298p.

A study was conducted of the use of radioisotope power as a heat source for saline water conversion. An economic feasibility study was made on this type of energy. The most economical source appears to be from the calcined fission product waste from processed spent reactor fuel elements. The results indicated that, for special conditions, this source of heat is competitive with conventional fuels. Results are presented of various studies on compatibility, thermodynamics, nuclear, and materials aspects of a full-scale heater utilizing calcined radioisotope waste products. The studies have permitted the conceptual design of a nuclear heater capable of supplying the thermal requirements for a one million gallon per day saline water conversion unit operating at 200 kwh/1000 gal. The design of a laboratory test model is given. The model will be capable of producing 250 gallons per day using one megacurie of cerium-144 and a six-stage flash evaporation conversion unit. A hazards analysis of the test model is included.

Comisión Nacional de Energía Nuclear, Mexico City.

41 (NP-15834) BIBLIOGRAFIA SOBRE LA CONVERSION DE AGUAS SALADAS Y SALOBRES EN AGUA DULCE (1954–1964). (Bibliography on the Conversion of Salt and Brackish Waters into Fresh Water (1954–1964)). Gurza, Tomas; Zamora, Pedro (comps.) (Comisión Nacional de Energía Nuclear, Mexico City (Mexico)). Nov. 1965. 178p. Dep. mn.

References (955) to various methods and equipment used for the desalination of water are given to reports, journals, and books published from 1954 through 1964. A separate author index is included.

Commissariat à l'Energie Atomique, Tunis (Tunisia).

42 (A/CONF.28/P/824) LES CENTRALES NUCLEAIRES UTILISEES AUX FINS DE DESSALEMENT DE L'EAU ET DE LA PRODUCTION DE L'ELECTRICITE; LEUR PERSPECTIVES DANS LES REGIONS ARIDES ET SEMI-ARIDES. (Nuclear Plants for Power and Saline Water Conversion; Their Prospects in Arid and Semi-Arid Regions). Chine, M.; Baklouti, M. (Tunisia. Commissariat à l'Energie Atomique, Tunis). May 1964. 8p.

Water requirements of industrial and domestic purposes are increasing, and in several cases water supply of these

regions by pipes is not the best solution; then, water conversion plants are to be considered among alternative water supply systems. Among energy sources required for water conversion plants, nuclear energy may be considered. Nuclear energy may offer advantages especially for dual purpose plant. Many problems of course have to be solved but reactors and saline water conversion plants technology at present time has no great difficulties to be solved. Generally it is possible to foresee types of reactors to be adapted for dual-purpose, processes for desalination which have the great experience, and the problems of connection of energy source and desalination plant. Some situations and especially that of Tunisia will be examined.

Department of the Interior, Washington, D. C. and Atomic Energy Commission, Washington, D. C.

43 PROGRAM FOR ADVANCING DESALTING TECHNOLOGY. Report to the President. U. S. Department of the Interior and U. S. Atomic Energy Commission. September 22, 1964. 55p.

The Department of the Interior proposes a broad-gage, accelerated program of action designed both to discover new techniques for desalting and to improve existing processes for the benefit of large and small communities. Emphasis will be given to the development of the most promising large-scale distillation processes. The Atomic Energy Commission proposes the development of large-scale nuclear energy systems for combination power-water application in coordination with the development of desalting processes by the Department of the Interior. The heavy water moderated, organic cooled reactor offers the best potential at this time for large power-water application.

Division of Reactor Development (AEC), Washington, D. C.

44 (TID-20039) REPORT OF LARGE LOW-PRESSURE STEAM REACTOR REVIEW GROUP. (Division of Reactor Development, AEC). Mar. 1963. 38p.

Capital costs, fuel cycle costs, and operating costs are reviewed for light water-moderated and -cooled pressurized reactors, and graphite- and heavy water-moderated reactors for steam production for water desalination. Dual-purpose (desalination and electric power production) operations were not considered. The current status and near-term potentials, effect of scaling-up of size, and the research and development programs are reviewed. No determination was made as to the reactor concept that would be best suited to desalting plants.

Division of Technical Information Extension (AEC), Oak Ridge, Tenn.

45 (TID-3567) SALINE WATER CONVERSION. A Literature Search. Raleigh, Henry J. (Division of Technical Information Extension, AEC). Nov. 1961. 29p.

A bibliography is presented on the developments in the production of potable water from saline or brackish waters. The 372 references cover literature through September 1961. The report references are arranged alpha-numerically under the corporate authors. The journal references are arranged alphabetically by title.

Du Pont de Nemours (E. I.) and Co., Aiken, S. C. Savannah River Lab.

46 (DP-830) AN EVALUATION OF HEAVY-WATER-MODERATED POWER REACTORS. Status Report as of March 1963. Babcock, D. F.; Hood, R. R.; Isakoff, L.; Jensen, J. C.; St. John, D. S.; Wade, J. W. (Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Aiken, S. C.). June 1963. Contract AT(07-2)-1. 124p.

Heavy-water-moderated reactors are attractive candidates for vigorous development and commercialization in the U S. nuclear power program. By virtue of their excellent neutron economy and their ability to operate on simple, massive, low-cost fuel elements, these reactors offer the potential of energy generation costs that are lower than those attainable in other converter reactors, higher conversion ratios than any other converter reactor, a self-sustaining breeding cycle with Th fuel, and low-cost steam for process heat applications such as desalination. It is concluded from consideration of estimated energy generation costs, neutron economy, present status of technology, and the extent of available development facilities that liquid D_2O and an organic liquid are the best candidates for further development as coolants for D_2O-moderated reactors.

47 (DP-866) HEAVY WATER REACTORS FOR SEAWATER DISTILLATION PLANTS. St. John, Daniel S.; Ross, Charles P.; Wade, James W. (Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Aiken, S. C.). Jan. 1964. Contract AT(07-2)-1. 58p.

Conceptual designs of reactors moderated with D_2O were prepared for a study of the use of large reactors for seawater distillation. Two designs are presented: a near-term reference design producing 3500 MW thermal with pressurized liquid D_2O coolant, and a more advanced design producing 8300 MW thermal with organic coolant. Steam costs are estimated for dual-purpose plants in which the by-product steam from back-pressure turbines is sent to the saline water plant. These estimates show that the net steam cost varies from 11 to 16¢/million Btu for the 3500-MW(t) plant, and from 4 to 9¢/million Btu for the 8300-MW(t) plant, as the power credit changes from 3 to 1 mill/kwh.

Ebasco Services, Inc., New York.

48 EVALUATION OF ALL POTENTIAL SOURCES OF ENERGY FOR DESALTING. Reichle, Leonard F. C. (Ebasco Services Inc., New York). 22p. (CONF-651005-3). ORAU. Gmelin, AED-CONF-65-276-5.

From 1st International Symposium on Water Desalination, Washington, D. C.

The alternate sources of fresh water are discussed; and it is concluded that with rising cost of obtaining additional supplies of fresh water, it is necessary to develop methods to remove contamination from brackish water or seawater to assure that the requirements for fresh water be met. Both major and minor sources of energy available for desalting are discussed and evaluated. Charts are presented to show various aspects of the use of the major sources of energy, fuel energy required by various desalting processes, etc. It is concluded that an established electric utility can produce the lowest cost electricity or steam for desalting, and charts and discussion are presented to show what kind of plant could best carry out the process.

Fluor Corp., Ltd., Whittier, Calif.

49 (PB-161010) PRELIMINARY DESIGN STUDY OF AN OPTIMUM NUCLEAR REACTOR-SALINE WATER EVAPORATOR PROCESS. (Fluor Corp., Ltd., Whittier, Calif.) Research and Development Progress Report No. 34. 1959 234p. OTS.

An engineering design study was made of a 50×10^6 gallons/day sea water conversion plant employing a multi-stage flash evaporator and a light water-moderated and cooled nuclear steam generator. It was necessary to select the optimum 370 Mw(th) reactor and to select the optimum capacity multi-stage flash evaporator that when combined with the optimum reactor system would produce fresh water at the least total cost. A preliminary design of a 1×10^6 gallons/day pilot plant was also prepared. The cost of potable water produced from sea water in a 5×10^6 gallons/day 52-stage flash evaporator is estimated to be $0.42 per 1000 gallons. This estimated cost includes all costs associated with the operation of the plant.

50 (PB-161062) STUDY OF THE APPLICABILITY OF COMBINING NUCLEAR REACTORS WITH SALINE WATER DISTILLATION PROCESSES. Research and Development Progress Report No. 19. Brice, D. B.; Dusbabek,

M. R.; and Townsend, C. R. (Fluor Corp., Whittier, Calif.). [nd]. Contract 14-01-001-97. 155p.

Activities in a program to select the two optimum-combination saline water reactor-conversion systems for further study and to indicate the direction of further research are reported. Results are presented of an investigation concerning the effects of power level on the cost of steam generated by natural U, heavy water-moderated and -cooled reactors. Studies of water cost from a multi-stage evaporator system are reported in which data were gathered indicating that sea water can be converted at 52 to 63 cents per thousand gallons in a 50 million gallon per day distillation plant utilizing steam from a nuclear reactor. It is also concluded that above 400 Mw the steam cost is relatively independent of power level. The two combination reactor-distillation systems which are considered optimum are the heavy water-moderated and -cooled reactor and the light water-moderated and -cooled slightly enriched reactor, incorporated with either a combination multiple-effect and multi-stage flash evaporator system or a long-tube vertical multiple-effect evaporator system.

General Dynamics Corp., San Diego, Calif. General Atomics Div.

51 APPROACHES TO THE CONVERSION OF SEA WATER TO FRESH. Bray, Donald T.; and Johnston, Thomas A. (General Atomic Div., General Dynamics Corp., San Diego, Calif.). 23p. (CONF-650249-4; GA-6294).

From American Power Conference, Chicago.

Discussion is presented on two methods for the desalination of sea water: dual-purpose plants making use of the High Temperature Gas-cooled Reactor (HTGR) as the heat source and reverse osmosis, a membrane process. Process description, performance, and economics are considered.

52 (GA-6294) APPROACHES TO THE CONVERSION OF SEA WATER TO FRESH. Bray, Donald T.; and Johnston, Thomas A. (General Atomic Div., General Dynamics Corp., San Diego, Calif.). Apr. 15, 1965. 22p. Presented at the American Power Conference, Chicago, April 27-29, 1965.

Descriptions are given of two methods under investigation for the economic desalination of sea water. One method utilizes the High Temperature Gas-cooled Reactor (HTGR) in a dual purpose-multistage flash evaporation plant. Typical performance data and water costs that could be expected from large plants of this type are presented. The description and economics of a reverse osmosis process are given and a brief qualitative comparison is made between the two desalination systems.

General Electric Co., Richland, Wash. Hanford Atomic Products Operation.

53 (HW-78388) ANALYTICAL STUDIES AND ADVANCED CONCEPTS. p.3.1-15 of RESEARCH AND DEVELOPMENT PROGRAMS EXECUTED FOR THE DIVISION OF REACTOR DEVELOPMENT. Quarterly Progress Report, April-June 1963. Hendrickson, M. M.; and Green, J. K., eds. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). July 1963. 133p.

Computer studies indicated that plutonium-enriched ^{238}U or ^{232}Th oxide fuels that have sufficient ^{240}Pu concentration will not suffer an economic disadvantage when ^{238}U is replaced with alloying or diluent materials. A reduced spatial concentration fuel containing ^{238}U and ^{232}Th enriched with plutonium was studied to determine fuel cycle costs and reactivity response characteristics. Costs for thermal energy supplied to a desalinization plant were determined for two reactor sizes, 3500 and 8300 Mw(e). Fuel cycle costs, reactivity, conversion ratio, and breeding ratio calculations were made for a revised 300 Mw(e) fast reactor using supercritical-pressure water as the coolant.

54 (RL-SA-21) APPLICATIONS OF NPR TECHNOLOGY TO THE NATIONAL NUCLEAR PROGRAM. Kosmata, H. R. (General Electric Co., Richland, Wash. Hanford Atomic Products Operation). Feb. 2, 1965. Contract AT(45-1)-1350. 2p. (CONF-650602-3). Dep. mn; CFSTI, $1.00 cy, $0.50 mn.

From American Nuclear Society 11th Annual Meeting, Gatlinburg, Tenn.

The fitting of the N reactor in the total national nuclear program is discussed. Possible power ratings and applications of the N reactor to desalination are discussed.

General Electric Company, San Jose, Calif.

55 POTENTIAL OF BWRs AS LOW COST HEAT SOURCES FOR DESALTING PLANT APPLICATIONS. Crever, F. E.; McNelly, M. J.; and Miller, E. H. (General Electric Co., San Jose, Calif.). 23p. (CONF-650429-3).

From American Power Conference, Chicago.

Data are presented on the application of boiling water reactors to dual purpose plants, with emphasis placed on the costs of steam to the desalting plant for a wide range of pressures. The costs were computed on the basis of recently published information on product line boiling water reactors. The trend toward lower water desalting costs with lower steam pressures to the desalting plant is noted. This trend has been confirmed, for certain conditions, in the case of boiling water reactor applications. Further appraisal of this characteristic of dual purpose plants has been attempted in order to assess the reasons therefore and to better define the most economical plant arrangement. The water production costs predicted by applying the present-day BWR to the water cost estimating methods are comparable to those computed for future nuclear reactor concepts of several times the unit size (25,000 vs. 3,400 Mw(t)). Water production costs from medium size dual purpose installations based on present-day boiling water reactor technology may well fall within the range of economic feasibility based upon a computed 1975 power credit of 3.86 mills/kwh (private ownership).

56 BOILING WATER REACTOR. White, G. (General Electric Co., San Jose, Calif.). 20p. (CONF-660311-3). ORAU. Gmelin, AED-CONF-66-037-2.

From Symposium on Water Production Using Nuclear Energy, Tucson, Ariz.

The boiling water reactor, as one of the lowest cost sources of thermal or electric energy available for desalting projects, has been the subject of numerous evaluations over the past few years. The energy cost, which can constitute 30–50% of the total cost of desalted water and can also directly influence the capital investment in the desalter, continues to show a downward trend. Boiling water reactors are now competitive with other energy sources using less than 20¢/MBtu fuel. In consequence, these BWRs can supply heat at ~200°F from the turbine exhaust for less than 10¢ per 1000 pounds of steam. During the past year or so, the rate of BWR commitments has built up to a level of over 2,500 MWe per annum. The design of BWRs required for desalting plants differs very little from these commitments for central station applications. It is concluded that the past few years of encouraging development of the various desalting plant concepts have been paralleled by a comparable gain in BWR operating experience and performance capability, thus further helping maximize the overall promise of current desalting program efforts.

Gosudarstvennyi Komitet Po Ispol'zovaniyu Atomnoi Energii SSSR.

57 TECHNICAL AND ECONOMIC ASPECTS OF THE USE OF NUCLEAR REACTORS FOR DESALINATION OF WATER AND ELECTRIC POWER GENERATION. Loginov, A. A.; Koryakin, Yu. I. (State Committee on the Utilization of Atomic Energy, USSR). pp 60-73 of STI-DOC–10/51.

The general properties of dual-purpose plants are briefly discussed. Methods for determining the cost of fresh water and electric power are briefly described. An analysis was made of the prime cost of fresh water and electric power. The results are presented.

Growth Industry Shares, Inc., Chicago.

58 STRATEGIC ECONOMIC FACTORS IN PLANNING NUCLEAR POWER FOR DESALTING SEA WATER. Mullenbach, Philip. (Growth Industry Shares, Inc., Chicago). 19p. (CONF-660321-1). ORAU. Gmelin, AED-CONF-66-148-1.

From Canaveral Council of Technical Societies, 3rd Space Congress, Cocoa Beach, Fla.

The role of nuclear power in seawater desalting in the U. S. during the next decade is examined considering certain conditions relating to alternative supplies, technology and scale-up, and the specific market for water. Emphasis in the cost evaluation is placed on the development of large dual-purpose power-water desalting plants.

Hittman Associates, Inc., Baltimore, Md.

59 ECONOMICS OF SMALL NUCLEAR ELECTRIC-DESALINATION PLANTS. Baer, Robert L.; Solberg, Donald E. (Hittman Associates, Inc., Baltimore, Md.). 8p. (CONF-650602-82). ORAU. Gmelin, AED-CONF-65-125-112.

From American Nuclear Society 11th Annual Meeting, Gatlinburg, Tenn.

The economics of small (10 to 15 Mw(t)) nuclear plants which produce electricity and desalinate water were studied for the purpose of quantitatively determining the cost of electricity and water produced by small dual-purpose nuclear plants and to compare these to actual water and electricity prices for representative locations. It is concluded that there are many places where such plants are economically attractive compared to existing electric and water production units. These small dual-purpose plants are also as attractive as pilot plants because of their modest capital costs.

Indiana University, Bloomington.

60 ECONOMICS OF WATER PRODUCTION USING NUCLEAR ENERGY. Milliman, J. W. (Indiana Univ., Bloomington). 38p. (CONF-660311-4). ORAU. Gmelin, AED-CONF-66-037-5.

From Symposium on Water Production Using Nuclear Energy, Tucson, Ariz.

The various technical and economic factors which affect the supply of freshwater are examined. The economic principles for the use and development of water resources and the economics of desalting are discussed. Cost considerations are examined for the choice of desalting processes, fossil versus nuclear fuels, single purpose versus dual purpose plants, and how costs are allocated between water and power in a dual purpose facility. Some of the economic aspects of the Bechtel study of a dual-purpose nuclear plant for Southern California are reviewed.

International Atomic Energy Agency, Vienna (Austria).

61 DESALINATION OF WATER USING CONVENTIONAL AND NUCLEAR ENERGY. A Report on the Present Status of Desalination and the Possible Role Nuclear Energy May Play in This Field (International Atomic Energy Agency, Vienna). Technical Report Series No. 24. 1964. 56p. STI/DOC/10/24. $1.00; Sch 21; 6s. stg; F. fr. 4; DM 3.20 (IAEA).

A general review is presented of the status of desalination of water at the end of 1963. The water needs of the world are discussed with examples of areas which need water and power. The various desalination processes are considered. An outline is given of large existing plants all over the world. The design and arrangement of large desalination plants are discussed. Finally, economic considerations and conclusions are given.

62 STUDY ON THE POTENTIALITIES OF THE USE OF A NUCLEAR REACTOR FOR THE INDUSTRIALIZATION OF SOUTHERN TUNISIA. Technical Reports Series No. 35. (International Atomic Energy Agency, Vienna). 1964. 33p. $1.00; S21,-; 6/-stg; F.Fr.4,-; DM3,20 (IAEA). STI/DOC/10/35.

A preliminary study was made of the possible use of a nuclear dual-purpose installation for the production of both electric power and desalted water. The factors likely to have a bearing on the features of the plant are discussed. It is concluded that the minimum capacity of the largest generating unit for the network is 51-58 Mw, and that the water demand will vary between 12,000 and 22,000 m^3/day. Power and distilled water costs figure to be 3.5 millimes (8.5 US mills)/kwh and 45-77 millimes/m^3 ($0.40-0.70/1000 gal), respectively.

63 SUMMARY REPORT AND RECOMMENDATIONS. (International Atomic Energy Agency, Vienna). pp 1-15 of STI-DOC-10/51.

A summary of highlights of the latest developments pertaining to nuclear desalination and related topics is presented. Recommendations of the conference panel on the Agency's role and future activities in nuclear desalination are discussed.

64 THE DEVELOPMENT OF THE ELECTRICAL ENERGY DEMAND IN GREECE AND OF THE WATER SUPPLY OF THE ATHENS AREA. Delyannis, A. (International Atomic Energy Agency, Vienna). pp 105-9 of STI-DOC-10/51.

The power production and demands in Greece are briefly discussed. The use of a dual-purpose reactor is discussed.

65 NUCLEAR POWER ECONOMICS. (International Atomic Energy Agency, Vienna (Austria)). Bibliographical Series. Dec. 1964. 156p. STI/PUB/21/13. $3.00; S63,-; 18/-stg; F.Fr.12,-; DM10.50 (IAEA).

A total of 771 references, almost all with abstracts, is given to the literature published and/or abstracted during the period 1960-1963. The references are arranged into six sections dealing with general aspects, evaluation of power reactors, nuclear propulsion, water desalination, reactor materials, and other economic aspects. An author index is included.

Joint United States-Israel Power and Desalting Team.

66 (NP-14617) COMBINATION SEA WATER DESALTING AND ELECTRIC POWER PLANT FOR ISRAEL. (Joint United States–Israel Power and Desalting Team). Oct. 1964. 134p.

The economics of a dual-purpose electricity-desalination nuclear power reactor for use in Israel beginning about 1971 is analyzed. The concept studied employs flash distillation for desalination.

Kaiser Engineers, Oakland, Calif. and Catalytic Construction Co., Philadelphia, Pa.

67 ENGINEERING FEASIBILITY AND ECONOMIC STUDY FOR DUAL-PURPOSE ELECTRIC POWER-WATER DESALTING PLANT. PHASE I REPORT. Prepared for United States-Israel Joint Board. (Kaiser Engineers, Oakland, Calif., and Catalytic Construction Co., Philadelphia). Department of Interior Report No. 65-25-RE. July 1965. 151p.

It is shown that a dual-purpose power-water desalting plant in Israel with capacity of 200 megawatts salable power and 100 million gallons water per day ready for initial operation in 1971 and full commercial operation by mid-1972 is technically feasible. Based upon the conceptual design work performed, it was concluded that either a pressurized water or boiling water reactor would be technically suitable for the nuclear steam supply and that the desalting plant should be of the multi-stage flash type. Capital costs have been estimated for the dual-purpose plant and allowances have been made for the electrical power and water conveyance facilities beyond the dual-purpose plant boundaries. Water production costs have been estimated for fixed charge rates of 5 per cent, 7 per cent, and 10 per cent. Estimates were also made for fossil-fuel plants of compa-

rable size. For all fixed charge rates through 10 per cent, the unit cost of water from the selected nuclear dual-purpose plant was less than that from a fossil-fuel dual-purpose plant.

68 (66-1-RE) ENGINEERING FEASIBILITY AND ECONOMIC STUDY FOR DUAL-PURPOSE ELECTRIC POWER-WATER DESALTING PLANT FOR ISRAEL. (Kaiser Engineers, Oakland, Calif. Catalytic Construction Co., Philadelphia, Pa.). Jan. 1966. 302p. Dep. mn. CFSTI $2.00 cy, $1.50 mn.

For United States–Israel Joint Board.

The study was conducted in two phases. The first phase was directed toward determining the feasibility of a dual-purpose electric power-water desalting plant ready for commercial operation in Israel by mid-1972 and included: (1) comparisons of various dual-purpose nuclear power and desalting plants using the multi-stage flash evaporation process and selection of one of these plants (hereinafter referred to as the reference plant) for detailed evaluation, (2) comparison of this selected plant with a comparable fossil-fuel dual-purpose plant, and (3) a recommended development program to confirm certain desalting plant components and design criteria. The second phase was directed toward preparing a detailed evaluation of the reference plant and to develop information for use in preparing an application to funding agencies. During Phase II the conceptual design was refined and new estimates of the capital cost, annual cost, and the unit cost of water were prepared. In addition, several plant alternatives and factors important in the determination of the total annual cost were examined such as: (1) differences in the desalting plant design and in the cost of water resulting from the selection of either a boiling-water or pressurized-water reactor for the nuclear steam supply, (2) differences in the cost of water resulting from the selection of a concrete instead of a steel reactor containment building, (3) differences in the cost of water resulting from the selection of concrete instead of steel evaporator chambers, (4) review of the plant operating factor, (5) determination of the effect of seasonal seawater temperature on the capital cost and the unit cost of water, and (6) determination of the change in the cost of water which would result if potential decreases in the nuclear fuel cycle costs materialize. Included are the results of the Phase I work and the results of the above Phase II studies including the estimates of capital cost, annual cost, and the unit cost of water.

69 POWER PLANT CYCLES FOR DUAL-PURPOSE PLANT APPLICATIONS. Wilson, J. R.; Finke, J.; Platz, H. R. (Kaiser Engineers, Oakland, Calif.). 24p. (CONF-660546-2). ORAU. Gmelin, AEC-CONF-66-111-3.

From American Society of Civil Engineers, Water Resources Engineering Conference, Denver, Colo.

The economic and technical advantages of using extraction or exhaust steam from a nuclear power steam plant as a heat source for desalting water are discussed. The dual-purpose electric power–water desalting plant in Israel is described to illustrate these advantages.

Los Alamos Scientific Lab., N. Mex.

70 (LA-2733) A PRELIMINARY EVALUATION OF FAST OXIDE BREEDER REACTORS FOR SEA WATER CONVERSION. Sesonski, Alexander; Hammond, R. Philip (Los Alamos Scientific Lab., N. Mex.). Aug. 1962. Contract W-7405-eng-36. 80p.

In a reference concept for economic evaluation, a solid-oxide, fast breeder reactor is used to provide process steam for a multiple-stage flash evaporation water conversion plant. Water production costs are significantly reduced as the capacity is increased. At a capacity of one billion gallons per day, predicted costs range from 8 to 13 cents per thousand gallons, competitive with new large-scale conventional source projects. The generation of by-product electricity can lead to substantial reductions in these predicted costs.

Oak Ridge Gaseous Diffusion Plant, Tenn.

71 (K-D-1780) DESALINATION OF SEA WATER—EVAPORATOR PLANTS. Mitchell, B. E. (Oak Ridge Gaseous Diffusion Plant, Tenn.). May 1, 1963. Contract W-7405-eng-26. 56p. Dep.(mn); $3.00(cy), 2(mn) OTS.

An engineering evaluation was made of plants for producing 1 billion gallons of product water per day by the flash evaporation process. Conceptual designs and cost estimates were prepared for three different type plants: modular plant, compact plant, and multilevel plant.

Oak Ridge National Lab., Tenn.

72 (CONF-14[illegible]6) LARGE-SCALE SEA WATER CONVERSION USING NUCLEAR ENERGY. Hammond, R. Philip (Oak Ridge National Lab., Tenn.). [1963]. Contract [W-7405-eng-26]. 7p.

From American Chemical Society 144th National Meeting. Los Angeles, Calif., March–April 1963.

The economics of desalting processes for sea water using large nuclear reactors as a source of power for water distilling plants is discussed. It is pointed out that low-cost electric power could be obtained as a byproduct in such plants. It is suggested that a 3500 Mev pilot plant of the natural uranium type could be undertaken in a relatively short time and would produce water in the cost range under 20 cents/1000 gal and power for 3 mills/kwhr or less, after writing off development costs. It is also suggested that breeder reactors would ultimately produce the lowest cost energy, but would need a longer time for development. Cost estimates are presented using regenerative evaporation in multi-effect or flash type evaporators and natural uranium reactor or an advanced fast breeder reactor. The cost of water would be 9.8 cents/1000 gal or 6.1 cents/1000 gal, depending on the reactor type used.

73 (ORNL-3452) ASSISTANCE PROGRAMS. p. 240-51 of CHEMICAL TECHNOLOGY DIVISION ANNUAL PROGRESS REPORT FOR PERIOD ENDING MAY 31, 1963. (Oak Ridge National Lab., Tenn.). Sept. 20, 1963. 293p.

Fuel cycle costs were evaluated for a variety of reactor stations for the production of water and possibly electricity. The base case studied was a heavy-water-moderated, light-water-cooled, natural-uranium reactor using the nested tube element. Fuel cycle throughputs ranged from 1 to 30 short tons of uranium per day. The fuel cycle costs were also determined for the same fuel element when the irradiated fuel was discarded rather than processed at 10 and 30 tons per day, and when plutonium and depleted uranium replaced the natural uranium at 1 to 30 tons per day. An attempt was made to examine on a comparable basis a partially enriched fuel of the Dresden type at 10 tons per day. These studies indicated: unit costs are rapidly reduced by increase in production requirements; natural-uranium fuels have the lowest fuel cycle costs; and burnup and inventory are the major factors in fuel cycles for slightly enriched uranium.

74 (ORNL-3470) WATER DESALINATION PROGRAM. Douglas, D. A. (Oak Ridge National Lab., Tenn.). p.232-4 of METALS AND CERAMICS DIVISION ANNUAL PROGRESS REPORT FOR PERIOD ENDING MAY 31, 1963. (Oak Ridge National Lab., Tenn.). Nov. 11, 1963. 285p.

Fuel fabrication costs were estimated for the very large reactors proposed for water desalination. Fabrication of 18 metric tons of uranium per day into identical elements is an insignificant part of the cost of generating heat.

75 (ORNL-3783) WATER DESALINATION INFORMATION MEETING, FEBRUARY 23-24, 1965. Abstracts of Papers. (Oak Ridge National Lab., Tenn.). Feb. 1965. Contract W-7405-eng-26. 35p. (CONF-650206). Dep.; $2.00(cy), 1(mn) CFSTI.

Abstracts are presented of 15 papers which were given on water research and nuclear desalination. Some of the topics treated include hyperfiltration, polarization, $CaSO_4$ solubility in solutions, Ti corrosion, fuel cycle costs, reactor types, evaporators, and plant optimization.

76 (ORNL-3870, pp 191-3) DESALINATION. Douglas, D. A. Jr. (Oak Ridge National Lab., Tenn.).

Efforts were divided into three general categories: calculating fuel fabrication costs, developing fabrication processes for thin titanium tubing for evaporator-condensors, and evaluating fuel performance. Computer codes for fuel fabrication costs were extended to include the coextrusion of Zircaloy cladding with thorium, thorium–uranium alloy, or uranium. Metal fuel performance was surveyed to help define applications of metal fuels for large desalination reactors. Methods of producing fluted titanium tubing by roll forming, tube drawing, isostatic pressing, high-energy-rate forming, and press forming were evaluated.

77 (ORNL-3882) AN ECONOMIC STUDY OF THE PRODUCTION OF AMMONIA USING ELECTRICITY FROM A NUCLEAR DESALINATION REACTOR COMPLEX. Blanco, R. E.; Holmes, J. M.; Salmon, R.; Ullmann, J. W. (Oak Ridge National Lab., Tenn.). June 1966. Contract W-7405-eng-26. 54p. Dep. mn. CFSTI $3.00 cy, $0.50 mn.

One example of the use of large blocks of low-cost nuclear power predicted for the foreseeable future would be production of hydrogen and ammonia fertilizer by the electrolysis of water. The cost of ammonia production at a nuclear desalination site via electrolysis was compared with the cost using the conventional steam-methane reforming process. Factors studied included power cost, natural gas cost, production rate, return on investment, type of electrolytic cell, by-product oxygen credit, and transportation cost. Using electrolytic cells that operate at very high current densities, ammonia can be produced for $39/ton with power at 2.5 to 3.0 mills/kwhr. Such power costs are obtainable on an incremental basis from commercial light-water reactors. Large advanced reactors producing power at 1.6 mills/kwhr appear to be capable of producing ammonia competitive in the United States (assuming a credit for by-product oxygen) with steam-methane reforming using natural gas at 29 to 33¢ million Btu's. The average U. S. industrial natural gas price in 1963 was 34¢ per million Btu's. The production of hydrogen and ammonia fertilizer at a nuclear desalination site is considered sufficiently attractive to justify further study.

78 (ORNL-3962) ABSTRACTS OF PAPERS, WATER DESALINATION INFORMATION MEETING, MAY 10–11, 1966. Kraus, K. A.; Hammond, R. P. (Oak Ridge National Lab., Tenn.). Contract W-7405-eng-26. 66p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Abstracts of 15 papers presented on the water research and nuclear desalination programs are presented.

79 (ORNL-P-20) AN ASSESSMENT OF CERTAIN AVENUES OF IMPROVEMENT FOR NUCLEAR DESALINATION TECHNOLOGY. Hammond, R. Philip (Oak Ridge National Lab., Tenn.). [nd]. Contract [W-7405-eng-26]. 12p. (CONF-612-1).

From IAEA Panel on Use of Nuclear Energy in Saline Water Conversion, Vienna, Apr. 1964.

Analytical considerations are given of some areas of possible improvements in dual-purpose and water-only plants. The effects of product ratio (water to electricity) on the optimum turbine exhaust temperature, performance ratio, and cost of water were determined for several cases and are presented graphically. The effects of a power subsidy on the water costs were also determined. The use of a steam turbine to drive a vapor-compression evaporator in a water-only plant and the use of a single pressure vessel for both the reactor and evaporators in a dual-purpose plant are suggested.

80 (ORNL-P-1151) FACTORS AFFECTING ANALYSIS OF DUAL-PURPOSE DESALINATION PLANTS. Burwell, C. C.; Ebel, R. A.; Hammond, R. P. (Oak Ridge National Lab., Tenn.). [nd]. Contract [W-7405-eng-26]. 30p. (CONF-650420-1). Dep.(mn); $2.00(cy), 1(mn) CFSTI.

From 5th Panel Meeting on Use of Nuclear Energy in Saline Water Conversion, Vienna.

The advent of nuclear desalting stations will make possible an important new source of water from the sea. In each situation, however, it is important to determine how the proposed plant compares with alternative methods of supplying the needed water, and to optimize the plant design to fit the local needs. Some of the analytical tools and techniques that can be applied to these tasks are discussed. In the case of the dual-purpose plant producing power as well as water, the cost of steam must be allocated appropriately to the two products. Although this is a purely arbitrary choice, a method is presented which has the novel feature of apportioning heat cost so that neither water nor power cost is appreciably affected by changing the product ratio of the plant design. Although simple analytical models can assist in characterizing desalination plant systems, the details of design and optimization are greatly aided by computer techniques. The computer codes in use at the Oak Ridge National Laboratory for desalination studies are listed, and illustrated by examples.

81 (ORNL-P-1278) ECONOMIC ASPECTS OF NUCLEAR DESALINATION. Burwell, C. C. (Oak Ridge National Lab., Tenn.). May 3, 1965. Contract W-7405-eng-26. 18p. (CONF-650532-1). Dep. mn; CFSTI, $1.00 cy, $0.50 mn.

From Institute of Nuclear Materials Management Meeting, Cincinnati.

It may be stated that distilled water may be economically produced by distillation in a large dual-purpose nuclear facility. Projected water costs will be low enough for agricultural purposes if full advantage is taken of the favorable cost features of by-product electricity, natural uranium or breeder fuels, a large fuel-processing industry, and large-size construction. Further reductions in water cost will undoubtedly occur as the results of research and development are applied to the nuclear desalination industry.

82 (ORNL-P-2071) AGRICULTURAL WATER BY NUCLEAR DESALINATION AND TECHNICAL ROUTES TO ITS ACHIEVEMENT. Hammond, R. Philip (Oak Ridge National Lab., Tenn.). Mar. 14, 1966. Contract W-7405-eng-26. 25p. (CONF-660311-2). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From Symposium on Water Production Using Nuclear Energy, Tucson, Ariz.

The nature of technical achievements that are missing in the production of agriculture water by nuclear desalination is defined, and their difficulties are outlined. The urgency of the program is discussed.

83 (ORNL-TM-432) PRELIMINARY BACKGROUND STUDIES OF THE PROSPECTS FOR ECONOMICAL DESALINATION OF SEA WATER USING NUCLEAR ENERGY. Hammond, R. P., et al. (Oak Ridge National Lab., Tenn.). Nov. 1, 1962. Contract W-7405-eng-26. 33p. Dep.(mn); $2.00(cy), 1(mn) CFSTI.

Very large reactors supplying heat to evaporators seem likely to be capable of producing fresh water from the sea which is cheaper than can be anticipated from any other presently proposed method, and possibly cheap enough for irrigation. This likelihood is especially strong if production of electric power is combined with production of water. The low cost could be achieved, however, only if quantities of water are produced which are much larger than have heretofore been considered in the saline water program. The cost of such a project and the amounts of water and power concerned tend to approach the scale of large river development projects. It is probably economically practical for municipalities to construct dual-purpose plants for production of power and city water using current technology. These moderate-sized plants could be either nuclear or fossil-fueled. Intermediate size nuclear water plants might be useful as an instrument of foreign aid. Once constructed, such plants would be cheap to operate, especially if existing U. S. reactor fueling facilities were utilized. The small plants would serve as pilot plants for developing larger stations.

84 (ORNL-TM-465) PROSPECTS FOR SEA-WATER DESALINATION WITH NUCLEAR ENERGY. AN EVALUATION PROGRAM. Young, Gale; Hammond, R. Philip; Spiewak, I. (Oak Ridge National Lab., Tenn.).

Jan. 1963. Contract W-7405-eng-26. 32p. Dep.(mn); $2.00(cy), 1(mn) CFSTI.

An evaluation and preliminary design program is proposed for the application of large nuclear reactors to the distillation of seawater. The applicable technology of evaporation processes and low-fuel-cost reactors is surveyed and applied to the projection of the cost of producing fresh water in large plants.

85 (ORNL-TM-536) EFFECT OF MAXIMUM BRINE TEMPERATURE ON THE OUTPUT OF LARGE NUCLEAR STATIONS FOR PRODUCTION OF WATER AND ELECTRICITY. Spiewak, I. (Oak Ridge National Lab., Tenn.). Mar. 29, 1963. Contract [W-7405-eng-26]. 14p.

The effect of brine temperature on the cost of water from large municipally owned D_2O reactor stations was investigated. It was found that water costs from 25,000 Mwt stations varied between 11.7 and 12.6¢/1000 gal in the maximum brine temperature range of 160 to 350°F. By-product electric power was sold at 1.49 mills/kwhr. The optimum size of reactors for producing combinations of 1 to 3 billion gpd and 1000 to 5000 Mw[e] was determined. From these optima, incremental costs of producing power and water were computed.

86 (ORNL-TM-564) THE EFFECT OF SCALE-UP ON FUEL CYCLE COSTS FOR ENRICHED FUEL AND NATURAL URANIUM FUEL SYSTEMS. Culler, Floyd L. (Oak Ridge National Lab., Tenn.). Apr. 16, 1963. Contract [W-7405-eng-26]. 26p.

Cost differences between natural uranium and partially enriched uranium fuel cycles are discussed. The estimated costs for a 10 ton per day, single purpose fuel cycle for a reactor of the Dresden type using 1.5% enrichment (Core 1) are given. Burnup and inventory charges were calculated for advanced pressurized-water reactors.

87 (ORNL-TM-587) A PRELIMINARY STUDY OF FUEL FABRICATION COSTS FOR LARGE HEAVY-WATER-MODERATED REACTORS. Lotts, A. L.; Douglas, D. A., Jr. (Oak Ridge National Lab., Tenn.). Apr. 1964. Contract W-7405-eng-26. 43p.

The purpose of this limited study was to estimate the cost of fabricating fuel elements for very large process heat reactors intended for desalination of seawater. In concept, the reactor would be moderated by heavy water, cooled by light water, and fueled by natural uranium. The special case of using plutonium and depleted uranium as the fuel was also considered. The fuel elements were envisaged as being of the concentric-tube, Zircaloy-clad type, containing either vibratorily compacted natural UO_2 or 99.4% depleted UO_2 spiked with 0.6% PuO_2; costs were estimated for three reactor sizes: 3500, 25,000, and 100,000 Mw(t). Fabrication plants were conceived, operational methods were established, processing times and labor were estimated, and the future cost of Zircaloy was predicted. From this analysis the cost of natural-uranium fuel fabrication, not including uranium or UO_3 costs, was estimated to be $15.55, $9.62, and $5.35 per kilogram of uranium for 3500-, 25,000-, and 100,000-Mw(t) reactors, respectively. The cost of PuO_2–UO_2 fuel fabrication, including all operations from sol-gel-produced oxide to finished elements but not including plutonium, uranium, or PuO_2–UO_2 costs, was estimated, per kilogram of uranium plus plutonium, to be $19.83, $12.15, and $6.30, respectively.

88 (ORNL-TM-609) PRODUCTION OF FERTILIZER IN A MULTIPURPOSE ATOMIC POWER REACTOR COMPLEX FOR DISTILLATION OF SEAWATER: A SURVEY. Blanco, R. E. (Oak Ridge National Lab., Tenn.). July 3, 1963. Contract [W-7405-eng-26]. 37p.

A survey was made to determine the feasibility of producing large amounts of nitrogen, phosphate, and potassium fertilizers with the cheap power produced from a large atomic reactor. The optimum combination was a multipurpose plant to produce fresh water from seawater by distillation and fertilizer from the air, sea, and phosphate rock. No other raw materials are required and only the three principal fertilizers containing nitrogen, phosphorus, and potassium are produced. Large amounts of by-products, requiring shipment and sale, are not produced. The arc process is used for nitrogen fixation from air to produce nitric acid and fresh water is electrolyzed to produce hydrogen for nitrogen fixation from air as ammonia. Ammonium nitrate can be formed as the final product. Alternatively, nitric acid could be produced by oxidation of ammonia instead of the arc process, if cheaper. Dicalcium phosphate or triple superphosphates are produced by nitric acid leaching of phosphate rock or by treating phosphate rock in an electric furnace with coke and silica. In the furnace process, coke must be shipped in as a raw material but silica would be available at oceanside locations. Potassium is recovered from seawater by precipitation of potassium dipicrylamine. Acidification of the precipitate with nitric acid produces potassium nitrate and the dipicrylamine is freed for reuse. Potassium can also be precipitated as magnesium calcium potassium phosphate but additional caustic must be shipped in to neutralize the phosphoric acid. The effect of reducing power costs per kwh from 8 to 10 mills for private industry or from 4 mill/kwh for TVA to 1 mill at a large multipurpose reactor station was estimated. The use of electrical power to replace natural gas as a process heat source was also assumed. Reductions in ammonia or dicalcium phosphate prices of less than 5% were predicted since these processes use large amounts of natural gas as process heat which has a cost equivalent to 1 mill/kwh. Conversely, however, the use of 1 mill/kwh electrical power would permit production of economical fertilizer at locations where natural gas is unavailable or must be conserved. The reduction of power cost from 4 to 1 mill/kwh decreased the cost of triple superphosphate produced in electric furnaces by 13%. This cost was estimated to be 16% cheaper than for superphosphate produced by the conventional sulfuric acid process at a Florida location. The cost of producing ammonium nitrate, a very desirable solid form of fertilizer suitable for long distance shipment, was estimated. The cost, by the electrolysis of water (at 1 mill/kwh) to produce hydrogen, fixation of nitrogen and hydrogen as ammonia, and oxidation of ammonia to nitric acid route, was estimated to be about 50% higher than the present method which uses natural gas as a raw material to produce hydrogen. Since these steps are modern engineering techniques, little further reduction in cost is expected. Hence, the production of nitric acid by arc fixation of air is the key item which could potentially reduce costs significantly for the whole complex but one which could not be estimated with accuracy without a detailed cost estimate and design survey. At 1 mill/kwh, the power cost alone for arc fixation of nitrogen is $0.029/lb N. Thus arc fixation nitrogen might be competitive with ammonium nitrate but not with ammonia which sell for $0.104 and $0.056/lb N, respectively. Since only 3% of the total energy of the arc process is used for nitrogen fixation, the wasted heat could be used to distill seawater and thus reduce the cost of nitrogen fixation. However, the reduction in cost of nitrogen fixation may be small since the energy is degraded before return to the distillation system. For example, if 30% of the heat is recovered as high temperature steam (worth $0.41 mill/$kwh_h$ or 120 mill/10^6 Btu) and 20% is useful as process heat (worth $0.034 mill/$kwh_h$ or 10 mill/10^6 Btu) the reduction in total cost of power for nitrogen fixation (using 1 mill/kwh_e) is 13%. Increasing the efficiency of the arc process (i.e., the yield of nitrogen/kwh_e) is considered the best means for decreasing the cost of nitric acid produced by the arc method.

89 (ORNL-TM-678) PARTIALLY ENRICHED FUEL CYCLES. Culler, Floyd L. Jr. (Oak Ridge National Lab., Tenn.). Sept. 3, 1963. Contract W-7405-eng-26. 45p. (CONF-178-1).

From European Atomic Energy Society's Symposium on Fuel Cycles for Power Reactors, Baden-Baden, Germany, Sept. 1963.

The lowest fuel cycle costs for converter reactors can be achieved by use of natural uranium fuels in heavy water-moderated reactors of very large size. Natural uranium fuel cycles operated at cycle capacities of 10 t/d and larger offer overall fuel costs that are small, about

0.05 mill/kwhr thermal, or 0.18 mill/kwhr electricity at 28% thermal efficiency. These costs assume 14%/yr charge on capital, a 5.5% charge on consumable inventories, burnup of 7000 Mwd/ton of uranium and a plutonium credit of $6.70/g. If plutonium is not recovered but discarded, the costs are approximately 0.9 mill/kwhr electricity. Plutonium can be recovered and recycled with depleted uranium to the same reactor system for approximately 20% increase in fuel cycle costs over the natural uranium case. This natural uranium cycle is probably a factor of five less costly than the least expensive partially enriched uranium case if plutonium (where initial ^{235}U is 1.5 wt % or higher) is recovered and sold; a factor of two less than the least expensive enriched case if plutonium is not recovered, particularly in fuel cycles of less than several tons per day capacity; and its attractive economically if the plutonium produced is recycled with depleted uranium.

90 (ORNL-TM-735) REGIONAL WATER SUPPLY BY NUCLEAR DESALINATION. Hammond, R. Philip (Oak Ridge National Lab., Tenn.). Nov. 26, 1963. Contract [W-7405-eng-26]. 19p. (CONF-187-23).

From American Nuclear Society Meeting, New York, Nov. 1963.

Comparison of nuclear desalting plants with conventional water supply projects now proposed for the southwestern United States shows that the nuclear stations are at least competitive in some areas, and this competitive position will improve as water needs increase and nuclear costs come down. An independent study made for the Office of Science and Technology confirmed the Oak Ridge National Laboratory's estimates of low energy costs from very large reactors.

91 (ORNL-TM-784) COST STUDY OF A LARGE SODIUM COOLED FAST BREEDER REACTOR FOR A SEA WATER DESALINATION PLANT. Gall, W. R. (Oak Ridge National Lab., Tenn.). Mar. 1964. 56p. Dep. (mn); $3.00 cy, $0.50(mn)CFSTI.

A very rough preliminary design study and cost estimate are presented for a 25,000 MW(t) plutonium fueled fast breeder reactor for use in a desalination plant. Designed for operation with sodium temperatures below 800 F, the primary system can be constructed of carbon or low alloy steels. The reactor vessel is 44 ft inside diameter, and with a coolant temperature rise of 260 F, four pumps circulate 2,400,000 gpm of sodium through four 6250 MW once-through steam generators. Saturated steam at 600 psia drives eight 540 MW(e) turbine-generator units, exhausting at 25 psia to the evaporator plant. Estimated direct construction costs per thermal kW are:

Reactor with primary coolant system only	$5.672
Turbine generator plant	4.726
Secondary sodium system	2.419

Top charges add approximately 40 per cent to these costs.

92 (ORNL-TM-787) SOME NOTES ON MIXED OWNERSHIP OF DUAL-PURPOSE POWER-DESALINATION PLANTS. Spiewak, I. (Oak Ridge National Lab., Tenn.). Oct. 14, 1963. Contract [W-7405-eng-26]. 13p.

Estimates of the cost of dual-output nuclear desalination plants are presented, based on projected costs of boiling H_2O cooled heavy water reactors and multistage flash evaporators. Several combinations of private and public ownership of the facilities are shown. Plants in the size range 1050 to 25,000 MW thermal are considered.

93 (ORNL-TM-826) A COMPARISON OF MULTI-STAGE FLASH AND LONG-TUBE VERTICAL MULTIPLE-EFFECT EVAPORATORS UNDER IDENTICAL CONDITIONS. Van Winkle, R. (Oak Ridge National Lab., Tenn.). Jan. 30, 1964. Contract W-7405-eng-26. 12p. Dep. mn; CFSTI, $1.00 cy, $0.50 mn.

Detailed cost estimates of a multi-state flash evaporator (MSF), and long-tube vertical multiple-effect evaporator (LTV) were used as a basis for comparing these two types of evaporators. Although the cost estimates were both for one billion gpd plants, the steam temperatures and maximum brine temperatures specified for the two plants were different (mainly because the specifications were written at two different points in time). Hence it was necessary to modify the MSF flowsheet to the steam, maximum brine and seawater temperature conditions of the LTV to permit making a normalized cost estimate for the MSF. Comparison of the systems was made for evaporators using 246°F steam, 230° maximum brine temperature, and 80°F seawater; the LTV had six effects, and the MSF had 42 stages. For the assumptions of this study, the principal findings are: (1) Although the LTV requires about one-third more heat transfer surface than the MSF, its total construction cost was less −247 million vs 269 million dollars for the MSF. (2) The LTV, having a larger fraction of its total capital cost in aluminum brass tubing, which might have to be replaced once during the 30 or 35 year lifetime of the whole plant, requires a higher fixed charge rate for interim replacement—about 1 to 1.2% vs about 0.8 to 0.9% for the MSF. (3) The cost of water produced in the LTV of performance ratio 5 lb product/1000 Btu is about 2¢/1000 gal cheaper than that of the MSF; this margin is obtained primarily as the result of lower pumping and chemical treatment costs. This difference is small relative to the accuracy of the two estimates; use of higher performance ratios would improve the MSF economics relative to those of the LTV.

94 (ORNL-TM-994) ESTIMATION OF INTERIM REPLACEMENT COSTS OF DUAL-PURPOSE NUCLEAR-ELECTRIC SEA WATER CONVERSION STATIONS. Reed, S. A.; Moyers, J. C. (Oak Ridge National Lab., Tenn.). Dec. 1964. Contract W-7405-eng-26. 33p. Dep.(mn); $2.00(cy), 1(mn) OTS.

Expected useful lifetimes have been obtained or estimated for typical components of dual-purpose nuclear-electric, seawater conversion stations. The component lifetimes were used to prepare tables of sinking fund factors, based on procedures published by the Bureau of Reclamation, for computing the costs of interim replacement of equipment for stations having lifetime expectancies of 30 and 50 years. Employing these sinking fund factors for 4% interest rate, annual interim replacement costs were calculated for a nuclear-electric plant using a 3220 MW(t) pressurized water reactor, for a 25,000 MW(t) nuclear plant comprised of three pressure tube reactors, and for two multistage-flash evaporator seawater conversion plants which had rated outputs of 165 and 1000 MGD respectively. At 4% interest rate, the annual replacement costs for 30-year-life plants, expressed as percent of initial investment, were estimated to be 0.27 and 0.42% for the 3220 and 25,000 MW(t) nuclear-electric plants, respectively, and 0.33 and 0.38% for the 165 and 1000 MGD seawater conversion plants, respectively, exclusive of heat exchange surface. For 50-year-life stations, the annual replacement costs were 0.51% for the 3220 MW(t) plant, 0.81% for the 25,000 MW(t) plant, and 0.41 and 0.46% respectively for the 165 and 1000 MGD evaporator plants, exclusive of heat exchange surface. The annual replacement cost for the entire evaporator plant, including heat exchange surface, is strongly influenced by the choice of tube and tubesheet material. The annual replacement deposits for the 165 and 1000 MGD conversion plants with copper-base alloys were 2.1 or 2.6% of the initial investment, respectively, for 30-year-life plants, and 2.2 or 2.6%, respectively, for 50-year-life plants. The annual deposit for the 1000 MGD plants would be 0.14 and 0.17% for the 30- and 50-year-life plants, respectively, if titanium were used.

95 (ORNL-TM-1057) ESTIMATION OF ANNUAL OPERATING AND MAINTENANCE COSTS OF DUAL-PURPOSE NUCLEAR-ELECTRIC SEA WATER CONVERSION STATIONS. Reed, S. A.; Moyers, J. C. (Oak Ridge National Lab., Tenn.). Apr. 1965. Contract W-7405-eng-26. 12p. Dep.(mn); $1.00(cy), 1(mn) CFSTI.

Estimates of the operating and maintenance costs of dual-output nuclear desalination plants are presented, based on projected manpower requirements, supplies, and maintenance materials for base-load stations having 90% plant factor. Two multistage flash evaporator plants have been considered; a 165×10^6 gpd plant coupled to a 3220 MW(t) nuclear-electric plant powered by a pres-

surized water reactor, and a 10^9 gpd evaporator plant operated with a 25,000 MW(t) nuclear-electric plant which was powered by three pressure tube reactors.

96 (ORNL-TM-1143) A 3500-MW(t) LOW-TEMPERATURE SODIUM-COOLED FAST BREEDER REACTOR FOR DESALINATION. Olson, R. C.; Carlsmith, R. S.; Hoskins, R. E. (Oak Ridge National Lab., Tenn.). June 10, 1965. 71p.

Preliminary design and economic studies of a 3500-MW(t) low-temperature sodium-cooled fast breeder reactor concept for use in desalination applications are reported. The reactor consists of an oxide-fueled core and metallic uranium radial blankets operating at a reactor inlet temperature of 500 F and a mean outlet temperature of 800 F. Four applications of the reactor design are considered:

1. Central-station power plant
2. Dual-purpose plant
3. Self-contained plant
4. Single-purpose process-heat plant

Based on proposed desalination ground rules, this system produces prime steam for less than 9 cents per million Btu. As a central station power plant, the system is capable of producing power at 1.5 mills/kwhr. If power is valued at this price, process heat in the form of steam at 280 F can be delivered to an evaporator plant for about 9.5¢/MBtu from the single-purpose process heat plant, 8.2¢/MBtu from the self-contained plant, and less than 5¢/MBtu from a dual-purpose plant producing 420 MW(e) over and above the auxiliary power requirements of the desalination complex.

97 (ORNL-TM-1152(Rev.)) A PRELIMINARY INVESTIGATION OF LOW-TEMPERATURE, LIGHT WATER-COOLED AND MODERATED, SLIGHTLY-ENRICHED URANIUM METAL FUELED REACTORS FOR LARGE SINGLE-PURPOSE NUCLEAR DESALTING PLANTS. Chapman, R. H.; Gift, E. H. (Oak Ridge National Lab., Tenn.). Dec. 1966. Contract W-7405-eng-26. 41p. Dep. mn. CFSTI $3.00 cy, $0.65 mn.

Low-temperature, light water-cooled and moderated, slightly enriched U metal fueled reactors show significant savings in capital and fuel cycle costs in relatively large, single-purpose desalting plants. A preliminary study was performed to determine current fuel limitations and approximate heat costs. Reactors of 1500 and 3500 MW(t), sufficient for producing 150 and 350 Mgd of fresh water, respectively, when coupled to water plants having performance ratios of about 10, were studied. With reactor coolant temperatures in the range of 250 to 350°F, significant savings in reactor plant capital costs result from the low pressure required to suppress boiling and the relatively low energy content of the coolant to be contained. This temperature range also permits direct coupling of the water plant to the primary coolant circuit through the brine heaters, thus eliminating the cost of an intermediate heat transfer system. The effects of density and self-shielding of lumped uranium metal in relatively dry lattices are to increase the fast fission effect and the conversion ratio, resulting in higher neutron economy and lower fuel cycle cost. Fuel cycle costs will be in the range of 4.40 to 5.90¢/MBtu for the 1500 MW(t) reactor and 3.85 to 5.40¢/MBtu for the 3500 MW(t) reactor. The range is reported to reflect uncertainties in the physics calculations and burnup level. Thus it is expected that heat cost will be in the range of 13.5 to 15.5¢/MBtu for the the 1500 MW(t) reactor and 10.0 to 11.5¢/MBtu for the 3500 MW(t) reactor

98 (ORNL-TM-1244) FLASH: AN IBM-7090 CODE FOR COMPUTING MULTI-STAGE FLASH EVAPORATOR PLANT DESIGNS FOR THE DESALINATION OF SEAWATER. Easterday, R. J. (Oak Ridge National Lab., Tenn.). Sept. 1965. Contract W-7405-eng-26. 87p. Dep. mn: CFSTI $3.00 cy, $0.75 mn.

An IBM-7090 code, FLASH, was written to optimize the design of a multi-stage flash evaporator saline water conversion plant. For an assigned water production, successive heat and material balance solutions and associated costs are computed to determine the optimum design. The output consists of listings of the heat and material balance results and of the comparative cost data. The code was originally written by the Bechtel Corporation.

99 (ORNL-TM-1321) A COMPARISON OF ALTERNATIVE COMPUTER CODES FOR THE DESIGN OF SALINE WATER CONVERSION PLANTS UTILIZING THE SINGLE-EFFECT, MULTI-STAGE FLASH-EVAPORATOR PROCESS. Easterday, R. J.; Griffith, W. L.; Keller, R. M.; Winsboro, R. B. (Oak Ridge National Lab., Tenn.). Jan. 1966. Contract W-7405-eng-26. 40p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Alternative computer programs for the process design of saline water conversion plants using the single-effect, multi-stage, flash-evaporation process were reviewed to determine areas where there are substantial differences in numerical approach or engineering assumptions. Comparisons of the numerical procedure utilized were made, and comparative results were calculated for typical design data. The major causes of the differences observed were pinpointed as differences in engineering approach.

100 (ORNL-TM-1329) FEASIBILITY OF OFFSHORE DUAL-PURPOSE NUCLEAR POWER AND DESALINATION PLANTS. Arnold, H. G.; Gall, W. R.; Morris, G. (Oak Ridge National Lab., Tenn.). Jan. 1966. Contract W-7405-eng-26. 112p. Dep. mn. CFSTI $4.00 cy, $0.75 mn.

The results of a study of the economic and technological feasibility of offshore desalination-power plants are presented. The use of a 3500-MW(t) organic-cooled heavy-water-moderated reactor as the heat source for a 733-MW(e) plant with an output of 2.5×10^8 gal/day of fresh water was considered.

101 (ORNL-TM-1373) RESEARCH AND DEVELOPMENT PROBLEMS IN THE USE OF CONCRETE FOR EVAPORATOR SHELLS. Bender, M.; Gall, W. R.; Merkle, J. G.; Northup, T. E. (Oak Ridge National Lab., Tenn.). Jan. 1966. Contract W-7405-eng-26. 83p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Preliminary studies of large desalination plants have indicated that substantial capital cost benefits may be realized through the use of concrete shells for evaporator installations. The feasibility of using concrete for this purpose hinges primarily on the ability of the concrete to retain adequate physical properties at elevated temperatures and to withstand thermal stresses caused by temperature gradients. The effects of seawater and distilled water on the surfaces of the concrete must also be determined for the elevated temperatures that will exist in certain portions of the evaporator. An experimental program was developed to obtain the information needed to design and construct a prototype plant. The proposed program would cost approximately $4.5 million and extend over a period of four years. The objectives of this program and a survey of the problems anticipated in the design, construction, and operation of desalination plant evaporator shells constructed of concrete are presented.

102 (ORNL-TM-1542) ORSEF: A FORTRAN CODE FOR THE CALCULATION OF MULTI-STAGE FLASH EVAPORATION DESALINATION PLANT DESIGNS. Mothershed, C. T. (Oak Ridge National Lab., Tenn.). Mar. 1966. Contract W-7405-eng-26. 130p. Dep. mn. CFSTI $4.00 cy, $1.00 mn.

A program was written for the IBM-7090 that determines the operating characteristics, geometry, and cost of a multi-stage flash desalination plant. The plant contains three major components: the brine heater; the evaporator recovery section; and the evaporator reject section. Using the costs of these components and input unit energy costs, the program can calculate the optimum balance between heat consumption, condenser area, and power usage. The output from the code defines the process parameters, costs, and design features of interest.

103 (ORNL-TM-1561) SURVEY OF PROCESS APPLICATIONS IN A DESALINATION COMPLEX. Holmes, J. M.; Ullmann, J. W. (Oak Ridge National Lab., Tenn.). Oct. 1966. Contract W-7405-eng-26. 68p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

A survey of the chemical and metallurgical industries

was made to ascertain which processes should be given priority for further detailed study as possible components of a nuclear industrial-desalination complex. Factors studied included market potential, demand for large quantities of power or steam, shipping costs, production costs, and economics expressed as turnover ratios.

104 (ORNL-TM-1564) FLEXIBILITY IN PRODUCTION OF POWER AND WATER FROM NUCLEAR DESALTING PLANTS. Franzreb, J. K.; Spiewak, I. (Oak Ridge National Lab., Tenn.). Sept. 1966. Contract W-7405-eng-26. 63p. Dep. mn. CFSTI $3.00 cy, $0.65 mn.

Flowsheets were developed for flexibility in the product output of dual-purpose nuclear desalting plants with base-load rating 500 MW(e) and 250 M gal/day. The base plant has a 3228 MW(t) pressurized water reactor, a back-pressure turbine-generator, and a multi-stage flash evaporator. The performance and cost of alternative systems for providing flexibility were evaluated by means of a computer model of the plant. Among the systems investigated were variable back pressure turbines, optional low pressure condensing turbines, pumped storage, turbine bypass desuperheaters, optional evaporator modules, vapor compression and heat pumps. Some of these systems appeared to be useful for providing economical peak power, for spinning reserve, in trading power for water, or in operating at mismatched product demand.

105 (ORNL-TM-1615) COST ALLOCATION PROCEDURE FOR DUAL-PURPOSE POWER-DESALTING PLANTS. Burwell, C. C.; Hammond, R. P. (Oak Ridge National Lab., Tenn.). Nov. 1966. Contract W-7405-eng-26. 29p. (CONF-660449-1). Dep. mn. CFSTI $3.00 cy, $0.65 mn.

From IAEA Panel on Costing Procedures for Nuclear Desalination, Vienna, Austria.

A procedure for the allocation of the total cost of a power-desalting plant to the separate products is described. The cost of producing the energy required by both products includes the cost of rejecting waste heat. The production cost of energy in the form of prime steam is divided between the cost of power and water according to its potential for producing electric power. Common facilities not associated with the production of energy are allocated to water and power costs according to the use or benefit that each product receives. The method has the characteristic that for an energy source with a given capacity the water-to-power production ratio may be varied over a range of values without significantly changing the cost of either product as long as the temperature of the heat supplied to the water plant is within the useful range for the process being used. The characteristic is due to the fact that: (1) since the energy cost component of power cost is constant for a given energy source, the unit power cost varies in the relatively minor effect of the equipment and operating unit costs of the power station as a function of size; (2) the variation in exhaust steam cost to the water plant as a function of exhaust pressure is balanced by a variation in the water plant design (if optimum) to match the water plant efficiency with the cost and condition of its heat source.

106 (ORNL-TM-1618(Pt.1)) NUCLEAR DESALINATION DUAL-PURPOSE PLANT CONTROL STUDIES. Interim Report. Ball, S. J. (Oak Ridge National Lab., Tenn.). Oct. 1966. Contract W-7405-eng-26. 79p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Methods were developed for predicting the dynamic behavior of a large dual-purpose plant consisting of a pressurized-water reactor (PWR), a back-pressure turbine generator plant, and a multistage flash (MSF) evaporator. A flexible digital computer code was developed which calculates the transfer functions for single-effect MSF plants. Preliminary results were obtained for a 250-megagallon reference plant and some of the major control problems were determined. An analog computer study was made of a reference PWR plant, and transfer functions for a large back-pressure turbine were derived.

107 (ORNL-TM-1627) OROSEF: A FORTRAN CODE FOR OVERALL DESIGN OF THE MULTI-STAGE FLASH DESALINATION PLANT. Mothershed, C. T. (Oak Ridge National Lab., Tenn.). Oct. 1966. Contract W-7405-eng-26. 80p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

A Fortran IV code was written to design a multi-stage flash desalination plant consisting of a brine heater which receives heat from an external source and transfers it to the brine, an evaporator recovery section which produces the major part of the product water and recovers heat to permit the plant to operate at performance ratios greater than one, and the evaporator reject system which rejects the heat to the coolant while producing a minor portion of the total product water. The code is used to calculate process flows and temperatures, heat transfer coefficients, plant geometry, and water cost.

108 (ORNL-tr-1173) OPTIMUM DIMENSIONING OF DUAL-PURPOSE PLANTS FOR THE PRODUCTION OF DESALINATED WATER AND ELECTRICITY WITH THE USE OF NUCLEAR ENERGY. Gaussens, J. (Commissariat a l'Energie Atomique, Paris (France)). Translated for Oak Ridge National Lab., Tenn., from paper presented at IAEA 5th Panel on the Utilization of Nuclear Energy in Water Desalination, [1965]. 33p. Dep. mn. JCL $3.60 fs, $1.19 mf.

An economics study was made for the nuclear production of desalinated water. Separate discussions are presented on the following; shape of the demand curves, the characteristics of supply and principles of adaptation of supply and demand.

Oak Ridge National Lab., Tenn. and Oak Ridge Gaseous Diffusion Plant, Tenn.

109 (ORNL-3501) FUEL CYCLE COSTS FOR A PLUTONIUM RECYCLE SYSTEM. Harrington, F. E.; Arnold, E. D.; Brater, D. C.; Douglas, D. A.; Smiley, S. H.; Stockdale, W. G.; Ullmann, J. W.; Lotts, A. L. (Oak Ridge National Lab., Tenn. and Oak Ridge Gaseous Diffusion Plant, Tenn.). Jan. 20, 1964. Contract W-7405-eng-26. 37p.

The costs of the chemical and metallurgical steps in the fuel cycle for large desalination reactors are estimated. Both capital and operating costs are presented at varying plant capacities for a Zircaloy-clad fuel element containing depleted uranium and recycled plutonium as the oxides: $UO_2-0.5\%\ PuO_2$. The chemical steps are reported at throughputs of 1, 10, and 30 short tons of uranium per day; and the metallurgical or fabrication step at throughputs of 1, 3, 5, and 10 tons per day, as specified by the Office of Science and Technology. The total estimated cost of all the chemical and metallurgical steps drops from $51.17 to $14.68 per kilogram of uranium as the cycle throughput is increased from 1 to 10 tons of uranium per day. All steps decrease in cost as plant capacity is increased, with the most impressive decrease in the irradiated assembly processing step, which decreases from $26.19 to $4.10 to $2.07 per kilogram of uranium as throughput is changed from 1 to 10 to 30 tons of uranium per day. The contained data in conjunction with previous studies of a natural uranium fuel cycle and results of a current reactor optimization study will yield complete fuel cycle costs and plutonium value in recycle.

Office of Saline Water, Washington, D. C.

110 (NP-16148) POTENTIALITIES AND POSSIBILITIES OF DESALTING FOR NORTHERN NEW JERSEY AND NEW YORK CITY. (Office of Saline Water, Washington, D. C.). June 1966. 112p.

The Northeast water supply situation and the drought problem are reviewed. Large dual-purpose, nuclear-fueled desalting plants of 300 MGD capacity can be built as a long-range solution to the need for additional water supply. Alternative water supplies, such as the Hudson River and small desalting plants, are discussed and found to be adequate for the present. However, additional desalting studies are needed.

111 (NP-16250) POTENTIALITIES AND POSSIBILITIES OF DESALTING FOR NORTHERN NEW JERSEY

AND NEW YORK CITY. A Report by the Northeast Desalting Team. (Office of Saline Water, Washington, D. C.). Feb. 11, 1966. 112p. Dep.

The potentialities and possibilities of desalting are considered as a source of water supply to the area of New York City and the four northern counties of New Jersey. Desalting is explored in terms of its cost and relationship to the growing need for water and electrical power, the existing surface water supply system, and proposed additions to the surface system. Various design configurations, including nuclear, fossil, and refuse-disposal fuel sources and dual-purpose power-water production, are considered.

112 (NP-16361) SALINE WATER CONVERSION REPORT, 1965. (Office of Saline Water, Washington, D. C.). 322p. GPO $1.50.

Research progress on saline water conversion is reported under the headings of chemical physics, biosciences, chemistry, applied science, materials, distillation, membranes, special projects, engineering services, engineering analyses, and program analysis and coordination.

113 (PB-161373) DEMINERALIZATION OF SALINE WATERS. (United States Department of the Interior). Oct. 1952. 66p. $1.75(OTS).

Potential separation processes and energy sources for demineralization of seawater are outlined and discussed. A chronological bibliography of demineralization methods containing 217 references dating from 1909 is included.

114 (PB-181546) CONVERSION OF SALINE WATER. A BIBLIOGRAPHY OF LITERATURE RESULTING FROM THE ACTIVITIES SPONSORED BY THE OFFICE OF SALINE WATER. Kase, Karel A. (Department of the Interior, Office of Saline Water). October 1963. 59p.

A bibliography is presented of those monographs, scientific and technical reports, papers and periodical articles which are a result of the activities of the Office of Saline Waters or which were written by a staff member of that Office. The bibliography which is arranged by author, is divided in two parts: I. Articles and Monographs, II. Reports, and is supplemented by author and subject indexes.

Sargent and Lundy, Chicago, Ill.

115 (SL-1998) SALINE WATER CONVERSION POWER REACTOR PLANTS. (Sargent and Lundy, Chicago). Jan. 11, 1963. For Oak Ridge National Lab., Tenn. Contract [W-7405-eng-26]; Subcontract [2086]. 201p.

Conceptual designs and construction cost estimates of two heavy-water-moderated, natural-uranium-fueled power reactor plants are reported. Both plants use vertical pressure tube reactors, in which heat is transferred to boiling light water, as heat sources. A part of the energy in the steam is converted to electrical energy in steam turbine-generators; the energy in the turbine exhaust steam is used to heat seawater in the turbine condensers. The seawater flows to an adjacent distillation plant for the production of fresh water. Two plant sizes are considered. One consists of a full-scale system designed to produce a power output of 25,000 thermal megawatts. The second system is based on a reactor having a thermal power output of 3,500 MW(t) and is considered to be a prototype of the larger plant. A preliminary composite flow diagram of the 25,000 MW plant is given. Three reactors, each designed for a heat power output of 8,333 MW, are used to produce 600 psi saturated steam for nine turbine generators. The turbines exhaust to nine brine heater-surface condensers at exhaust conditions of 17.2 psia, 220°F; the heat of vaporization is removed in the seawater by heating it from 185 to 200°F. The plant outputs are about 4,000 MW(e) to the switchyard and 20,300 MW(t) as 200°F seawater. The study includes all facilities for a complete power generating system, including the switchyard, control rooms, waste disposal systems, offices and shops in addition to the structures and systems associated with the reactor-turbine complex. The general layout of the plant is shown. Each reactor is contained in a separate containment structure, and all nine turbine-generators are located in a single containment building. The reactor buildings consist of vertical pre-stressed concrete cylinders, capped with hemispherical domes, while the turbine containment building is one-half of a horizontal steel cylinder, capped on the ends with spherical quadrants. In cross section, the turbine building is semi-circular with a flat concrete floor. The reactor and turbine containment structures form one containment volume for the expansion of reactor coolant in the event of a coolant system rupture. Based on the complete loss of coolant from one reactor, the building design pressure is 8.5 psig. Both the reactor and turbine buildings have double outer shells, with the space between the shells connected to a waste gas compression system, allowing leakage from the inner shell to be collected, monitored, passed through iodine filters and disposed of safely. The study includes necessary electrical auxiliaries, heating, ventilating and air conditioning systems, and plant utilities such as fire protection systems, and sewage systems. It is assumed that the seawater for the brine heaters and that used for miscellaneous cooling purposes in the plant is pumped to the power plant by pumps at the saline water evaporation plant. Power for these pumps is transmitted to the saline water plant by three 345 kV feeders from the switchyard. Approximately 200 MW(e) is estimated to be required for this service. The 3,500 MW plant uses one pressure tube reactor to produce saturated steam at 600 psi. Two 325 MW(e) turbine generators are driven by the steam, which condenses in brine heaters at 17.2 psia, 220°F before being pumped back to the reactor inlet as condensate. The heat of vaporization of the turbine exhaust steam is used to raise the temperature of the seawater from 185 to 200°F, as in the 25,000 MW plant. This system generates a gross power output to the switchyard of 574 MW(e). The output of 200°F seawater is about 2800 MW(t) under these conditions. The plant structures differ from those of the 25,000 MW plant, in that only the reactor systems are housed in a containment structure. The turbines are located on foundations that are outdoor structures, and the turbine-generators and auxiliaries are weatherproofed for outdoor service. The containment building for this plant has only a single containment barrier, and consists of a vertical cylindrical steel building 180 feet in diameter, enclosed at the top by a hemisphere and at the bottom by a hemiellipsoid. The design pressure of the containment building (18.5 psig) is based on instantaneous release of the entire reactor coolant inventory to the interior of the building. As provided for the 25,000 MW plant, the 3,500 MW system includes switchyard, control building, waste disposal systems, and offices and shops necessary for a complete power plant. It is assumed that pumping facilities for the seawater for condensing purposes and miscellaneous cooling services are provided at the evaporating plant. The estimated capital investments for the plants are $126,095,000 for the 3,500 MW plant and $607,787,000 for the 25,000 MW plant.

116 (SL-2008) ENGINEERING STUDIES HEAVY WATER MODERATED POWER REACTOR PLANTS. (Sargent and Lundy, Chicago). June 30, 1963. Contract AT(38-1)-213. 295p.

Design and economic aspects of 300-, 500-, and 1000-MW(e) heavy water-moderated power reactors are illustrated and the computer codes used in the analyses are discussed. The plant concepts all use pressure tube type reactors with cold heavy water as moderator and are cooled by: liquid heavy water, boiling heavy water, organic liquids, and light water fog. The liquid heavy water-cooled and organic-cooled reactors are used in an indirect cycle while the boiling heavy water- and light water fog-cooled reactors operate in a direct cycle. The use of large heavy water-moderated reactors as an energy source in desalination plants which would produce electrical power and fresh water is evaluated. Cost estimates together with several illustrations of the plant designs for this application are presented.

117 (SL-2158) LARGE CONDENSING AND NON-CONDENSING TURBINE PLANT STUDY. (Sargent and Lundy, Chicago). June 30, 1964. For Oak Ridge National Lab., Tenn. Contract [W-7405-eng-26], Subcontract 2148. 36p. Dep.(mn); $2.00(cy), 1(mn) OTS.

Costs and performance characteristics of three large turbine generator plants, two of which are designed for ex-

hausting steam to a desalination plant and the third is a conventional condensing unit, are discussed. Each of the units is rated nominally at 650 MW(e), and will be used in large dual-purpose reactor power plants.

118 (SL-2317) LARGE TURBINE PERFORMANCE AND TURBINE PLANT COST STUDY. (Sargent and Lundy, Chicago, Ill.). Dec. 1, 1965. Contract W-7405-eng-26. 62p. (ORNL-TM-1641). Dep. mn. CFSTI $3.00 cy, $0.65 mn.

For Oak Ridge National Lab., Tenn.

Performance data and cost estimates are developed for units employing large condensing and noncondensing turbine generators applicable to large nuclear dual-purpose power and desalination plants. The units studied have capacities ranging from 300 to 750 MW(e) and a variety of steam conditions and cycle arrangements.

Task Group on Nuclear Power and Saline Water Conversion.

119 AN ASSESSMENT OF LARGE NUCLEAR POWERED SEA WATER DISTILLATION PLANTS. (Task Group on Nuclear Power and Saline Water Conversion). Mar. 1964. 41p. $0.35(GPO).

A memorandum summarizes the findings, conclusions, and recommendations of the Task Group, and a report of the interagency subcommittee is presented. The studies indicate that water prices attainable using stations made up of 8,300-MW(t) dual-purpose reactors are 23¢ per 1,000 gal when all the plant complex is financed at a 7% fixed charge rate, or 28¢ per 1,000 gal when the reactor and water plants are financed at 14 and 7% fixed charge rates, respectively. The cost for irrigation appears to be 11¢ per 1,000 gal. Water conveyance costs are considered. It is emphasized that a station analysis for a specified proposed station would be required to determine the most practical plant. The research and development program required for dual-purpose reactor stations producing from 10 up to 620 MGD is described. The status of nuclear reactor technology and seawater distillation plants is examined. Desalting processes other than distillation are discussed briefly.

120 APPENDICES TO AN ASSESSMENT OF LARGE NUCLEAR POWERED SEA WATER DISTILLATION PLANTS. (Task Group on Nuclear Power and Saline Water Conversion). Mar. 1964. 484p. $3.25(GPO).

Technical design and performance data are given for dual-purpose power plants for 1500 to 25,000 MW(t) using boiling reactors, pressurized reactors, heavy water reactors, organic-cooled reactors, liquid metal-cooled reactors, high-conversion reactors, enriched-fuel reactors, and fast breeder reactors. Power value estimates for the dual-purpose desalination plants are presented. Methods of desalination are discussed. Evaluation of potential water markets in southern California coastal areas is considered. Federal Reclamation financial criteria are applied in assessing the large distillation plants.

Technion-Israel Inst. of Tech., Haifa.

121 (A/CONF.28/P/548) FEASIBILITY OF NUCLEAR REACTORS FOR SEA WATER DISTILLATION IN ISRAEL. Aschner, F. S.; Yiftah, S.; Glueckstern, P. (Israel Inst. of Tech., Haifa). May 1964. 19p.

Present power capabilities and future requirements in Israel are discussed. The heating requirements, performance ratios, and temperature limitations of flash evaporators for seawater distillation are considered. Dual-purpose nuclear reactors for power and desalination purposes and process heat reactors for low pressure steam generation for desalination are compared technically and economically with conventional steam generation in Israel. Investment costs based on these alternatives and the water prices expected are given.

Union Carbide Corp., Oak Ridge, Tenn. Y-12 Plant.

122 (ORNL-TM-1299) SALINE: A FORTRAN COMPUTER PROGRAM FOR THE PROCESS DESIGN OF SALINE WATER CONVERSION PLANTS USING THE MULTI-STAGE, FLASH-EVAPORATION PROCESS. Griffith, W. L.; Keller, R. M. (Union Carbide Corp., Oak Ridge, Tenn. Y-12 Plant). Nov. 1965. Contract W-7405-eng-26. 81p. Dep. mn; CFSTI $3.00 cy, $0.75 mn.

For Oak Ridge National Lab., Tenn.

A Fortran IV computer program that performs heat balance, material balance, and cost calculations on saline water conversion plants using the multi-stage, flash-evaporation process is described. The code is a modified revision of a program written by the Bechtel Corporation for OSW. Under the simplifying assumptions inherent in the mathematical model, a complete heat and material balance is calculated by a stage-to-stage numerical technique from the design parameters supplied. Costs are calculated from these results and the economic data supplied. Optimum design parameters which minimize total cost over a 30-year period can be determined either by a series of computer runs or by an optimization procedure supplied. Details of the numerical procedure, program options, and usage are presented. Results obtained with an IBM-7090 from typical design data and a complete listing of the Fortran program are included.

United Nations. Dept. of Economic and Social Affairs.

123 (ST/ECA/86) WATER DESALINATION: PROPOSALS FOR A COSTING PROCEDURE AND RELATED TECHNICAL AND ECONOMIC CONSIDERATIONS. (United Nations, Dept. of Economic and Social Affairs). 1965. 56p.

In view of the fact that desalinated water must by its very nature be relatively costly, both in terms of investment per installed unit of capacity and of total cost per unit of product water, it is particularly important that a clear and simple costing method should be devised which would allow policy makers and administrators to establish an approximate, but realistic, true cost for product water. The procedure outlined provides a tool which should make it possible to establish the cost of water from existing installations on a uniform basis, and which may thus be used as a guide for rate setting policies. At the same time, the method should be equally applicable to plants which are not yet built, but for which basic data are available and for which principal technical specifications can be provided by manufacturers or consulting firms. If an adequate system for costing water from conventional sources is available, as may well be the case in many countries, the procedure outlined should make it possible to compare the cost of desalinated water from a plant with given specifications with that of water from an alternative source for which it has been possible to establish the full cost per unit of product, using parameters comparable to those employed for desalination.

Westinghouse Electric Corp., Pittsburgh, Pa.

124 NUCLEAR POWER-WATER DESALTING PLANT AND THE ELECTRIC UTILITY INDUSTRY. Stinson, W. H.; O'Toole, J. D. (Westinghouse Electric Corp., Pittsburgh). 26p. (CONF-660429-4). ORAU. Gmelin, AED-CONF-66-098-5.

From American Power Conference, 28th Annual Meeting, Chicago.

The principles and status of technology of nuclear steam supply systems are reviewed; typical ranges of energy costs from such systems are presented; and some unique turbine-generator configurations and their influence on costs of energy supplied to the water desalting plant are discussed. In addition, the possibility of reactor "stretch" utilization and need for overall optimization in dual-purpose plants are discussed.

TRANSLATIONS

125 (AEC-tr-6733) ANALYSIS OF THE TECHNICAL AND ECONOMIC INDICES OF NUCLEAR-POWERED DESALINATION PLANTS. Loginov, A. A.; Koryakin, Yu. I.; Chernyaev, V. A.; Zakharov, I. I.; Stoyushchev, B. A.; Suponev, A. D. Translated from Paper SWD/56

Presented at 1st International Symposium on Water Desalination, Washington, D. C., October 3–9, 1965. 53p. (CONF-651005-8). Dep. mn. CFSTI $3.00 cy, $0.50 mn. JCL $5.60 fs, $1.79 mf.

A mathematical analysis was made of the basic components of the total cost of fresh water in a dual-purpose plant with the use of vertical evaporators and flash evaporation units.

126 (AEC-tr-6744) ANALYSIS OF THE THERMAL EFFICIENCY OF POWER PLANTS WITH HIGH-CAPACITY STILLS. Sterman, L. S.; Gubenko, V. V. Translated from Paper No. SWD/70 Presented at the First International Symposium on Water Desalination, October 3-9, 1965, Washington, D. C. 17p. (CONF-651005-19). Dep. mn. CFSTI $1.00 cy, $0.50 mn. JCL $1.60 fs, $0.80 mf.

A method is described which makes possible the establishment of parameters for the optimum thermal efficiency of two-loop dual-purpose atomic stations.

127 (JPRS-26497) PRELIMINARY TECHNICAL-ECONOMIC ESTIMATES ON COMPLEX UTILIZATION OF NUCLEAR POWER FOR DESALINATION OF SALT WATER AND SIMULTANEOUS GENERATION OF ELECTRIC POWER. Sinev, N. M. Translation of an address presented at a conference on "Utilization of Atomic Energy," Washington, D. C., August 16, 1964. 32p. (TT-64-41755).

Economic and technical aspects of dual-purpose desalination-power plants using several types of reactors are discussed. Fast-neutron, water-cooled and -moderated, water-graphite, and heavy water reactors are considered. It is shown that a fast reactor of 2,200 MW(t) output is the most economical for desalination of 180,000 to 220,000 m^3 of sea-water per day.

128 (JPRS-33406) THE USE OF REACTORS OF THE BELOYARSK ATOMIC POWER PLANT TYPE FOR DUAL-PURPOSE DESALINIZATION SYSTEMS. Koryakin, Yu. I.; Loginov, A. A.; Mikhan, V. I.; Monchinskii, A. G. Translation of Paper No. SWD/57 presented at the First International Symposium on Desalination of Water, Washington, D. C., October 3–9, 1965. 15p. (TT-65-33980). CFSTI $1.00 cy, $0.50 mn.

An evaluation of the power potentialities and economic indices of reactors of the Beloyarsk type gives grounds to consider these reactors to be very promising for a combined production of electric power and desalted water, especially under the conditions when these two types of the product are equally important and necessary.

129 (JPRS-33459) THE APPLICATION OF NUCLEAR POWER INSTALLATION FOR WATER DESALINATION WITH SIMULTANEOUS PRODUCTION OF ELECTRIC POWER. Dmitriev, I. D. Translation of Paper No. SWD/72 presented at the First International Symposium on Desalination of Water, Washington, D. C., October 3–9, 1965. (TT-65-34033). CFSTI $1.00 cy, $0.50 mn.

Among the versions under investigation utilizing turbines with controllable steam diversion, the most convenient seems to be the atomic energy station with fast neutron reactors producing desalinated water at a cost of 4.5 kop/m^3. The calculations do not pretend to shed complete light on the question under investigation, and consequently cannot be extended to all specific cases of fresh water production by means of nuclear reactor heat.

130 (JPRS-33480) NUCLEAR DESALINATION EQUIPMENT OF LOW CAPACITY. Polushkin, K. K.; Koryakin, Yu. I.; Kuznetsov, S. P.; Grozdov, I. I.; Sirotkin, A. P.; Loginov, A. A.; Khoroshavin, V. D.; Gasnikov, P. E.; Aleksenko, Yu. N. Translation of paper No. SWD/58 presented at the First International Symposium on Desalination of Water, Washington, D. C., October 3–9, 1965. 17p. (TT-65-34054). CFSTI $1.00 cy, $0.50 mn.

The results of a study of desalination plants using organic-cooled reactors of 15, 30, and 70 MeV are presented.

JOURNALS

131 DESALTING OF SEA WATER BY NUCLEAR POWER. Koppe, Johannes (Hamburgische Electricitaets-Werke Aktiengesellschaft, Hamburg). At. Strom, 12: 12-15(Jan.–Feb. 1966). (In German).

The development of suitable economic methods for the desalination of sea water is discussed. It is proposed that nuclear reactors can be used as energy sources for desalting installations because of their low fuel costs in large installations. Combined plants with simultaneous water desalination and current production offer the best economic potentials.

132 METHOD FOR CALCULATION OF WATER AND POWER COSTS FOR NUCLEAR DESALINATION PLANTS. Koryakin, Yu. I.; Loginov, A. A.; Chernyaev, V. A.; Zakharov, I. I. At. Energ. (USSR), 19: 138-43(Aug. 1965). (In Russian).

A method is given for determining the economic aspects of dual-purpose installations enabling an accurate separate estimate of the costs of power generation and fresh water production. The effect of the basic parameters of the installation on the cost of fresh water was analyzed. Economic indices are given for dual-purpose installations used with various types and various heat capacity reactors.

133 NUCLEAR POWER AND DESALINATION. Koryakin, Yu. I.; Loginov, A. A. At. Energ. (USSR), 20: 232-43(Mar; 1966). (In Russian).

The use of nuclear power in the desalination of sea water is discussed. Economic questions, possible engineering problems, distillation technology, and the efficiency of distillation installations are considered.

134 THE USE OF NUCLEAR REACTORS FOR SEA-WATER DISTILLATION. Biondi, L.; Vaudo, A. (Servizio Nucleare della Societa Montecatini, Milan). Atompraxis, 9: 328-32(Aug. 1963). (In English).

The possibility of using nuclear energy for distilling sea water is discussed. The first question considered is whether fresh water could be produced on an industrial scale, and if so, under which conditions. After an analysis of the various production-cost factors involved, the possible advantages of sea-water distillation by means of nuclear energy in comparison with conventional methods was examined.

135 ATOMIC ENERGY FOR AFRICA—A STUDY FOR EURATOM. To the Berlin Meeting on the Savary Report. Atomwirtschaft, 10: 425-6(Sept. 1965). (In German).

The economic possibilities for utilization of nuclear energy in the African countries associated with the European Common Market were investigated. The use of power reactors for electricity production, desalination of sea water, and for industrial heating and cooling, and the use of radioisotopes for agriculture and hydrology were studied.

136 POTENTIAL APPLICATION OF SALINE WATER CONVERSION IN AUSTRALIA WITH PARTICULAR REFERENCE TO THE USE OF NUCLEAR HEAT. Herbert, L. S. and Pratt, H. R. C. Australasian Engr., 65-72(July 1960).

A brief survey is given of proposed methods for the production of potable water from saline waters. It is concluded that vapor recompression distillation, electrodialysis, and in some cases solar distillation, represent the most suitable processes for domestic units, capable of outputs of about 50 to 500 gal/day. For large-scale plants, suitable for supplying large communities, distillation methods appear most suitable on the basis of existing technology, although electrodialysis would be applicable to brackish waters with salt contents below 5000 ppm. Freezing methods also show considerable promise. Preliminary design and cost studies are given for multistage flash evaporation plants employing nuclear reactors as the heat source, both without and with concurrent power generation by means of back-pressure turbines. It is shown that plants based on the 150 and 275 Mw(e) gas-cooled reactors currently being installed in Britain would produce respectively 44 and 80 million gallons per day of water together with 30 and 63 Mw of surplus power; the larger of these plants would be capable of providing a city of 500,000 population with the whole of its water and about 25% of its installed power capacity. Data are also given for a small plant based on a 50 Mw(th) pressurized water reactor employing U. S.

enriched fuel. In this case 4,000,000 gallons per day of water would be produced together with 2.6 Mw of surplus power.

137 APPLICATION OF ATOMIC ENERGY FOR THE DISTILLATION OF SEA WATER. Aquije, Carlos Hernández and Méndez, Augusto Mellando (Junta de Control de Energía Atómica, Lima). Bol. inform. junta control energía atómica, (Peru), 5: 114-19(May–June 1960). (In Spanish).

The utilization of nuclear power for the distillation of sea water is considered in its economic aspects. A pressurized water reactor combined with a flash evaporator is discussed as the reactor type. The characteristics of such a reactor are tabulated. The capital costs for the installation and operation of the reactor system for flash evaporation of sea water are given.

138 NUCLEAR HEAT FOR THE DESALTING OF BRACKISH OR SALT WATER. Leicester, J. Brit. Chem. Eng., 2: No. 7, 364-7(July 1957).

The possibility of using heat from a nuclear reactor in distillation and solvent extraction techniques of water purification is considered. Cost data are presented for an installation with an output of the order of 40 million gallons per day.

139 THE POSSIBLE ROLE OF NUCLEAR ENERGY FOR SEA WATER DESALINATION. Ertaud, Andre. Bull. Inform. A.T.E.N. (Assoc. Tech. Energie Nucl.), No. 53, 5-19(May–June 1965). (In French).

A cost comparison was made of nuclear and conventional power plants for the desalination of sea water. The simultaneous production of electricity and desalinated water, the efficiency of the natural uranium–graphite–gas reactor, the development of mixed nuclear power plants, and the types of reactor are considered.

140 THE ECONOMY. SOVIET ATOMIC POWER STATIONS. Vvedenskii, G. A. Bull. Inst. Study USSR, 12: No. 2, 33-8(Feb. 1965).

Nuclear power stations in the Soviet Union are described briefly. Economic aspects of using nuclear energy as a source of electric power are discussed. The program for use of heat from nuclear reactors for desalination of seawater is reviewed.

141 SALINE WATER DEMINERALIZATION AND NUCLEAR ENERGY IN THE CALIFORNIA WATER PLAN. Calif., Dep. Water Resources, Bull. No. 93: 1-145(Dec. 1960).

The various phases of the state of California's interest in nuclear energy and water demineralization as initiated through the work of two legislative subcommittees are described. The history, principal demineralization techniques, present and probable future water costs, and research and development programs, both state and federal, are described and discussed. The present status and future possibilities of nuclear energy applications are reviewed and discussed. The effect of nuclear energy in the coming 10 to 15 years on the California Water Plan is considered in detail. The types and possible use of so-called "nonconventional" sources of energy are reviewed and discussed, and their use in relation to the water program in the near future is discussed. The future program of the state in the development of water demineralization and nuclear energy applications is presented. Many tables and graphs are used to elucidate the various aspects of the report.

142 NUCLEAR PROCESS HEATERS LOOK HOPEFUL. Can. Chem. Process., 47: 39-40; 42(May 1963).

The economics of nuclear fuel as compared with electricity and coal are discussed. Fueling costs of 7c/million Btu have been demonstrated for nuclear reactors, compared to 30–40c/million Btu that most plants must pay for coal, oil, or natural gas. However, it isn't possible to get 7-cent steam in small units because of design considerations. The desalinization of water, paper mill process heat, light-water vs organic, and high-temperature heat are discussed.

143 DESALINATION: THE "POOR MAN'S" SPACE PROGRAM. Law, C. Arthur. Can. Nucl. Technol., 4: No. 3, 51-4(1965).

A survey of the current status of nuclear desalination technology indicates the main areas of world demand, the state of the art in the engineering and technology of large saline-water conversion plants, as well as results of recent research in the design of multi-stage flash and tube-type evaporators. A review is made of the effects of the application of process heat from nuclear reactors to the economics of large scale desalination, with special attention to the role of heavy water moderated "high convertor" reactors.

144 NUCLEAR HEAT TO DISTILL SALINE WATER? Chem. Eng. Prog., 54: No. 2, 87-9(Feb. 1958).

A condensation of a Fluor Corporation study to determine the best combination of reactors and distillation processes to produce the lowest cost water is presented. Desalinated water could be produced for approximately 63 cents per 1000 gallons by a heavy water-moderated and -cooled reactor combined with a seven-stage, long tube vertical, multiple-effect evaporator.

145 NUCLEAR REACTORS APPLIED TO WATER DESALTING. Ramey, J. T.; Carr, J. K.; Ritzmann, R. W. Combustion, 36: No. 4, 33-7(Oct. 1964).

Results of studies of dual purpose nuclear power-desalting plants and an outline of the development program for the next decade are presented. Current nuclear desalting technology and cooperative international exchanges are described which have the possibility of providing fresh water at less than 50 cents per 1000 gallons.

146 THE UTILIZATION OF RADIOISOTOPES AS AN ENERGY SOURCE FOR SALINE WATER CONVERSION. Welt, Martin A. (International Scientific Corp., Washington, D. C.). Dechema Monograph., 47: 373-414(1962). (In English).

Project Artesia proposes to convert fission product wastes into an energy source for saline water conversion. The radioactive aqueous waste material from reactor fuel element reprocessing plants is calcined to an insoluble powder and loaded by vibrational compaction into rods. A sufficient number of rods is loaded into a pressure vessel in which the heat is transferred to a suitable heat transfer fluid. This energy is then carried to a conventional saline water conversion system through an intermediate heat exchanger. The economic feasibility of an experimental test model is examined, and the cost is estimated to be $0.79/1000 gal. The technical aspects are next considered: radioactive material, materials selection, heat transfer, and compatibility analysis. Finally, the design and hazards of the experimental test model are described.

147 THE PRESENT STATE AND PROSPECTS OF UTILIZING NUCLEAR POWER. Levai, Andras. Energia Atomtech., 18: 121-34(Apr. 1965). (In Hungarian).

During the last 6 years dozens of atomic power stations, with a total capacity of about 5000 Mw(e), were built; their operating experience offers a basis for economic evaluation of their performance. It was concluded from data on these stations that the cost of the nuclear-generated electricity and heat is becoming competitive with energy derived from conventional sources, even though government subsidies played an important role in the development of the present plants. The main factors that contributed to the increasing importance of atomic power plants include: use of large reactors, up to 600 Mw; increasing cost of conventional fuels; prolonged periods of exploitation of the atomic power plants, and inclusion of these plants in interconnected networks. It is forecast that by 1970 about 25,000 Mw(e) and by 1980 up to 250,000 Mw(e) atomic power capacity will be available. Desalination of seawater is postulated to be one of the chief potential fields of application of atomic energy that will probably become completely competitive with other systems within the next two decades.

148 SPECIAL USE OF NUCLEAR POWER. Halzl, Jozsef. Energia Atomtech., 18: 187-9(Apr. 1965). (In Hungarian).

Papers at the Third Geneva Conference on specialized applications of atomic energy are discussed under three headings: desalination of sea water; atomic heating plants; and problems connected with the development of portable reactors. Economic investigations carried out in the United

States and Israel revealed that, depending on the cost of fossil fuels, fresh water may be produced competitively by reactors with a capacity between 220 and 600 Mw. A 1000-Mw desalination reactor is planned by the Soviet Union to be located near the Caspian Sea. Two reactors were constructed primarily for space heating: in Halden, Norway and Stockholm, Sweden. Similar work is in progress in the Soviet Union, basing the design on that of the Beloyarsk power reactor. The portable reactors are designed for operation in remote areas where high fuel costs make them competitive. The United States has five such reactors in operation. These reactors are characterized by low weight, small dimensions, portability, ease of assembly, long core life, and simple operation and maintenance. Ship propulsion reactors include that of the icebreaker Lenin. Design work on maritime reactors is in progress in Holland, sponsored by Euratom and in West Germany.

149 L'ADOUCISSEMENT DES EAUX MARINES ET SAUMATRES. Energie Nucleaire, 2: 262-4(July–August 1960). (In French).

Discussions are presented of two English desalination studies, a nuclear-powered distillation plant and an electrodialysis plant, and the American nuclear-powered distillation plant at Point Loma. The Fluor Corporation design study for a nuclear distillation plant of 208,000 cubic meters per day capacity is mentioned, and costs of water from the various types of plants are compared.

150 DESSALEMENT DE L'EAU DE MER. PERSPECTIVES D'UTILISATION DE L'ENERGIE NUCLEAIRE. Energie Nucleaire, 5: No. 3, 195-7(May 1963).

A summary is presented of five U. S. studies on the economic evaluation of reactors for the desalination of sea water utilizing the flash evaporation process.

151 ENERGIE NUCLEAIRE ET DESSALEMENT DE L'EAU DE MER. Energie Nucleaire, 6: No. 5, 328-30 (July–Aug. 1964).

A short review of estimated economies of single and dual purpose reactor-powered desalination plants is presented. A bibliography containing 17 references is included.

152 NUCLEAR REACTOR FOR DISTILLING SEA-WATER. Vilentchuk, Isaac; Arad, Nathan. Engineering, 185: No. 4810, 628-30 (May 16, 1958).

A pressurized-water reactor producing low temperature steam for distillation of sea water is shown to have highly favorable conditions of operation in arid and semi-arid countries. The constructional and technological features of the Low Temperature Reactor (LTR) are shown to be much simpler than for a power reactor, and certain features of the LTR are compared with those of a Shipping-port-type reactor. Cost data are analyzed for distilling water by a power reactor and by the LTR and are found to compare favorably.

153 DESALINATION TODAY AND TOMORROW. Streifler-Shavit, I. E. (Joint Sea-Water Desalting Project, Israel). Euratom Bull., 5: 66-72(Sept. 1966).

Present desalination processes and cost estimates for each are discussed. Desalination processes include electrodialysis, reverse osmosis, freezing, and evaporation. The best economic prospect is the construction of large combined plants in which nuclear energy is used to produce electricity and fresh water. A large nuclear dual-purpose plant is described and nuclear fuels are compared with fossil fuels.

154 NUCLEAR-POWERED ELECTRODIALYSIS FOR DESALINATION. Hitchcock, A. (Atomic Energy Establishment, Winfrith, Eng.); Minken, A. A. L.; Minken, J. W. Euro Nucl., 2: 79-84(Feb. 1965).

The extent to which electrodialysis can be an economic means of obtaining fresh water from salt water, when nuclear reactors are used as energy sources, is examined. Comparisons between electrodialysis and flash distillation as a means of obtaining large volumes of fresh water are presented. The two processes are shown schematically, and comments are made on the differences in plant behavior and product.

155 DESALINATION FOR THE FUTURE. Zibis, Dieter. Euro Nucl., 2: 134-5(Mar. 1965).

Uses of nuclear reactors to produce heat for distillation of sea water are discussed. World water requirements are also considered.

156 NUCLEAR DESALINATION PROSPECTS. Hitchcock, A. (Atomic Energy Establishment, Winfrith, Eng.). Euro Nuclear, 2: 533-6(Nov. 1965).

Sea water desalination processes are discussed. Flash distillation, multi-effect multi-stage flash distillation, scale control by distillation, multi-effect distillation, the theory of distillation, reverse osmosis, and electrodialysis are considered. Use of nuclear reactors as heat sources in desalination is discussed.

157 NUCLEAR POWER TODAY AND TOMORROW. Schwoerer, Frank Jr.; Witzig, Warren F. IEEE (Inst. Elec. Electron. Engrs.), Spectrum, 1: 120-30(July 1964).

The firmly established applications of nuclear power such as electric power generation, submarine propulsion, and space auxiliary power are reviewed. Several new areas of application including booster rockets for deep space, desalting of sea water, power packages for hardened sites, and underground explosions of nuclear devices are also discussed.

158 ECONOMICS OF DESALINATION. Baron, S. (Burns and Roe, Inc., New York). IEEE (Inst. Elec. Electron. Eng.), Spectrum, 3: No. 12, 63-70(Dec. 1966).

In an analysis of the thermodynamics of dual-purpose desalination plants, it is apparent that the base-loaded plant with noncondensing turbine provides the most economic approach to desalination even though new storage capacities will be required. Conveyance of water to existing reservoirs and variable operation of the water facility offer no economic advantages. Desalination of water is too expensive for agricultural applications, but it provides a promising source of fresh water for certain areas with special water problems where conventional supplies are inadequate to meet the needs of growing populations and increased industrialization. Thermodynamic comparisons of single-purpose power plants (fossil and nuclear); single-purpose water plants (fossil or nuclear); noncondensing dual-purpose (fossil and nuclear); and condensing dual-purpose (nuclear) plants are given.

159 NUCLEAR POWER FOR SALT WATER CONVERSION. Intern. At. Energy Agency Bull., 6: No. 2, 3-7 (Apr. 1964).

Various purification processes for salt water using reactor and conventional heat and electrical sources are described. Flash distillation, vapor compression, and electrodialysis are discussed. The relative merits of mixed installations that produced electricity as well as purified water are considered.

160 CYCLES FOR SUPPLYING STEAM TO DESALTING EVAPORATORS OF DUAL-PURPOSE POWER-GENERATION PLANTS. Leung, Paul; Moore, Raymond E. (Bechtel Corp., Los Angeles). J. Eng. Power, 88: 22-6 (Jan. 1966).

Feasible cycles for supplying low-energy-level steam to the desalting flash evaporators of dual-purpose electric-generation and seawater conversion plants are presented and discussed. Cycles which generate electricity as the primary product and desalted water as the by-product are compared with cycles which produce water as the predominant product and electricity as the by-product. Investigations include fossile-fueled steam cycles and nuclear-fueled steam cycles at various pressures and temperatures. Determination of the most feasible cycles for various capacity ranges of water production and electrical generation are presented.

161 NUCLEAR ENERGY: POTENTIAL FOR DESALTING. Ramey, James T.; Swartout, J. A.; Williams, W. A. (Atomic Energy Commission, Washington, D. C.). Mech. Eng., 88: No. 4, 52-5(Apr. 1966).

The development of nuclear power for desalination is discussed. The history of this development, the advantages of nuclear energy, the AEC program for desalting application, and the problem of technology scale-up are considered. Trends in costs of nuclear power plants, data from dual-purpose plant studies, fuel costs for light water

reactors, and the effects of the size of the nuclear fuel industry on fuel costs are given.

162 NUCLEAR DESALINATION. Ramey, James T. (Atomic Energy Commission, Washington, D. C.). Mech. Eng., 89: 107-9(May 1965).

The program to desalt sea water by nuclear energy is considered. It was found that with large dual purpose nuclear plants, power and water could be produced at competitive costs in water-short coastal areas by about 1975-1978 and that such installations would be valuable supplemental sources of municipal and industrial water. Dual-purpose plants fired by 200- to 1500-Mw reactors were studied. The advantages of dual-purpose plants were confirmed, and there seems to be a sound basis for combining the production of these two utilities, especially with nuclear reactors as the heat source. Better use of the available heat is made; economies are offered by building one large plant instead of two smaller plants to produce the two products; and savings in certain equipment are possible. A wide range of plant sizes and reactor types was investigated and various assumptions on factors such as fixed charge rates, value of power, and plant load factor were employed. Considerable variations in the resulting predictions of the costs of water and power were found. The predicted costs, however, proved to be encouraging, and nuclear desalting plants, especially those of a larger size, should be competitive with alternate methods of water supply. For example, a plant built for operation in 1970, which uses a 1500-Mw water-cooled reactor, is predicted to produce 190 Mw of electricity and 170 million gal/day of water at a cost of about 32¢ per 1000 gal. For a plant built for operation in 1975, which uses an 8300-Mw heavy-water reactor and produces about 1460 Mw of electricity and 620 million gal/day, the cost of water is predicted to be around 23¢ per 1000 gal. The electricity produced in a dual-purpose plant (the power value) can have a substantial effect on reducing water cost. For the plant using the 1500-Mw water-cooled reactor, the water price is lowered by about 2½¢ /1000 gal for every mill/kw-hr of power selling price increase. In the case of the 1500-Mw water reactor plant, the cost was found to increase from ~32¢ /1000 gal to 40¢/1000 gal when the entire plant load factor decreased from 80 to 60%. The reactor concept presently considered most promising for large-scale power desalting use in the heavy-water, organic-cooled reactor (HWOCR). The HWOCR concept offers significant potential for producing low-cost electric power and heat, especially in large single unit sizes. Because of its specific design features, extrapolation to a large-scale unit of up to 8 to 10,000 Mw capacity is considered technically feasible. The reactor also has the potential for very low energy costs whether used in power only or dual-purpose plants. As an advanced converter, the HWOCR also promises a substantial improvement in nuclear fuel utilization compared to present light-water reactors. It is expected that the initial prototype would be sufficiently developed to permit its operation in 1970.

163 DESALTING OCEAN AND SALINE WATERS. Emel'ianov, V. (Corresponding Member of the Acad. Sci. USSR). Nauka i Zhizn' No. 3, 20-3(March 1965). (In Russian).

Brief discussions are presented of desalination processes, and various desalting installations now in operation are mentioned. The economics of nuclear dual purpose plants are discussed. A 2,200 Mw(t) reactor in a dual purpose plant could produce 510 Mw(e) and 180,000 cubic meters of fresh water per day at a cost of 2 to 3 kopeks per cubic meter. Reactors in the range of 10,000 to 20,000 Mw(t) would produce water cheap enough to be used for irrigation.

164 FRESH WATER BY NUCLEAR POWER. Kronberger, Hans. New Sci., 28: 31-3(Oct. 7, 1965).

Flash distillation, using steam from an AGR, as a method for desalination of sea water is discussed. An advanced gas-cooled reactor and multistage flash distillation plant designed to yield 400 Mw of electricity and 60 million gallons of fresh water daily is described.

165 REACTOR DEVELOPMENT PROGRAMME FOR LARGE-SCALE DESALTING PLANTS. REPORT BY U. S. ATOMIC ENERGY COMMISSION. Nucl. Energy, 16-20 (Jan. 1965).

The objectives and achievements of the Civilian Nuclear Power Program are reviewed. The history of the use of nuclear energy for process heat and desalting is discussed, and international activities in this field are summarized. The proposed AEC reactor-development program for large-scale desalting is presented; the heavy-water moderated, organic cooled reactor offers the best potential for meeting the energy needs for large power-water situations. Estimated program costs through 1975 are summarized.

166 NUCLEAR ENERGY— POTENTIAL FOR DESALTING. Ramey, James T. (U. S. Atomic Energy Commission, Washington, D. C.). Nucl. Energy, 60-6 (Mar. 1966).

The development of nuclear energy for sea water desalting is discussed. Topics considered include nuclear and fossil energy resources, the advantages of nuclear energy, trends in nuclear plant and operating costs, the history of desalting using nuclear power, and the AEC program for desalting application. Also discussed are engineering studies of desalting installations, scale-up of the desalting technology, and the international program. The goals of this development are to provide a nearly inexhaustible resource of energy, and large quantities of pure water from the sea at reasonable cost.

167 DESALINATION AND THE ROLE OF NUCLEAR POWER. Nucl. Eng., 10: 191-3(May 1965).

A brief review is given of the vapor compression, flash distillation and falling film methods of desalination, and diagrams are presented of typical processes. A survey is presented of distillation plants in operation and under construction around the world and a comparison of dual purpose plants powered by various types of reactors is shown. U.S.A. brackish water feasibility studies, water desalination development in Israel, and U. K. economic feasibility studies are discussed.

168 APPLICATION OF NUCLEAR ENERGY TO LARGE-SCALE POWER AND DESALTING PLANTS. Siegel, Sidney; Golan, Simcha; Falcon, Joseph A. (Atomics International, Canoga Park, Calif.). Nucl. Eng. Design, 4: 225-32(Oct. 1966).

There is a current widespread interest in dual-purpose nuclear plants, attributable to successful developments in both the nuclear and desalination fields. During the past year, it has become clear that nuclear power can compete economically with fossil fuel power in many geographical areas. At the same time, parallel strides have been made in the technology and economics of seawater conversion, particularly in distillation processes. These developments have opened the way for consideration of large-scale plants which can supplement both the electrical energy and fresh water needs of large metropolitan areas near the coast. Specific types of nuclear power plants in combination with desalting plants are examined to establish the relative economic potential of various heat sources for large-scale dual-purpose application.

169 FEASIBILITY OF OFFSHORE DUAL-PURPOSE NUCLEAR POWER AND DESALINATION PLANTS. Arnold, H. G.; Gall, W. R.; Morris, G. (Oak Ridge National Lab., Tenn.). Nucl. Eng. Design, 4: 311-21(Oct. 1966). (ORNL-P-2517).

Discussion of the ecological and technical reasons suggests off-shore locations for dual-purpose nuclear power and desalination plants to be an attractive solution to the siting problem. A study on the feasibility of offshore construction of such dual-purpose nuclear plants shows that the necessary technological experience is available from applications for other purposes such as offshore oil wells, bridge caissons, floating dry docks, and other marine structures. Conceptual design studies for a large-scale nuclear power and desalination plant using alternatively an island caisson, a deep-water caisson, and a moored floating platform are described. Comparative cost estimates for onshore and offshore dual-purpose nuclear plants are made.

170 SCALE, NUCLEAR ECONOMICS AND SALT WATER. Weinberg, Alvin M.; Young, Gale (Oak Ridge

National Lab., Tenn.). ANS Nucl. News, 6: No. 5, 3-8 (May 1963).

The effects of large scale reactors on the economics of nuclear power and process heat generation are considered. The cost figures for a 25,000 Mw(t) dual-purpose plant producing 5000 Mw(e) and one billion gallons of fresh water per day are presented.

171 HEAVY-WATER REACTORS FOR PROCESS HEAT. ANS Nucl. News, 6: No. 5, 9-11(May 1963).

Tables and information are summarized from report DP-830 on the use of heavy-water reactors for both single and dual-purpose plants.

172 NUCLEAR APPLICATIONS TO SALINE-WATER CONVERSION AND THEIR ECONOMIC IMPLICATIONS. Baron, S. (Burns and Roe, Inc., New York). Nucl. News, 7: No. 4, 36-9(Apr. 1964).

The general design approach for application of nuclear energy to desalination of sea water is discussed. A survey is presented of nuclear desalination projects and studies. Technological problems, siting criteria, and reactor types are discussed in large-scale reactor development for desalination.

173 SUMMARY OF INTER AGENCY DESALINATION REPORT-CONFIRMATION OF THE PROSPECTS FOR NUCLEAR DESALINATION. Nucl. News, 7: No. 4, 40-1(Apr. 1964).

The conclusions and cost data presented in the Inter Agency Task Group study of large nuclear-powered sea-water distillation plants are summarized.

174 NUCLEAR DESALINATION ASPECTS. Hammond, R. P. Nucl. News, 7: No. 10, 55-6(Oct. 1964).

A summary is given of the Geneva Conference papers on the development of power reactors for desalination purposes.

175 LARGE REACTORS MAY DISTILL SEA WATER ECONOMICALLY. Hammond, R. Phillip (Los Alamos Scientific Lab., N. Mex.). Nucleonics, 20: 45-9(Dec. 1962).

Nuclear reactors in very large sizes hold out the promise of large-scale distillation of fresh water from the sea at a cost low enough for municipal, industrial, and irrigation uses. According to the results of a preliminary study, water in these cost ranges can be produced by breeder-reactor distilling plants if they can be built large enough—up to 100,000 Mw(th). The cost of water depends strongly on the size of the unit; for larger plant sizes, costs below $15¢/10^3$ gal may be possible.

176 A LARGE DESALINIZATION REACTOR BASED ON CURRENT TECHNOLOGY. Spiewak, Irving (Oak Ridge National Lab., Tenn.). Nucleonics, 21: No. 7, 64; 66; 68(July 1963).

A reference design for a reactor desalinization and power generation plant (particularly, the reactor design) is presented. The facility, based on current technology, would use three 8,333-Mw(t) heavy-water moderated, boiling-light-water-cooled reactors fueled with natural UO_2 to provide 4,500 Mw(e) of electricity and 2 billion gallons of water per day. Cost estimates for construction and operation are also included.

177 ECONOMICS OF REACTORS FOR POWER AND DESALINATION. Baron, S. (Burns and Roe, Inc., New York). Nucleonics, 22: No. 4, 67-71(Apr. 1964).

Capital costs, fuel costs, and costs for operation and maintenance are discussed for power-desalination dual purpose power plants.

178 ADVANCED REACTOR CONCEPTS. Nucleonics, 22: No. 10, 74-9(Oct. 1964).

A summary is given of the Geneva Conference papers on advanced reactor designs and concepts including nuclear superheat projects, fast-breeder reactors, heavy-water reactors. Applications such as water desalination and nuclear space power units are also discussed.

179 WHY NOT SINGLE-PURPOSE REACTORS FOR DESALTING. Baron, S.; Zizza, M. (Burns and Roe, Inc., New York). Nucleonics, 23: No. 9, 44-7(Sept. 1965).

The development of large single-purpose reactor-powered water plants is discussed. It was concluded that for a 100×10^6 gpd plant, water would cost ~40¢/1000 gal. The disadvantages of dual-purpose plants include production of large blocks of power, limits to flexibility of plant location due to power transmission costs, lower plant efficiency under certain operating conditions, and higher costs than single-purpose plants. A reactor design is proposed in which brine temperature is limited to 190°F. The reactor can be either light-water cooled and moderated with slightly enriched uranium fuel, or heavy-water cooled and moderated with natural or slightly enriched uranium fuel. Selected as basic design was an aluminum-clad natural UO_2 fuel, with D_2O as coolant and moderator. Multistage flash evaporator designs were studied and evaluated.

180 THE PROSPECTS FOR DUAL-PURPOSE PLANTS. Crever, Frederick E. (General Electric Co., San Jose, Calif.). Nucleonics, 23: No. 9, 48-50(Sept. 1965).

Dual-purpose nuclear desalting plants are considered in the light of fundamental thermodynamics and economics. The effects of size and duality are discussed, and the cost of steam considered. It was concluded that in areas requiring both power and water, dual-purpose plants with $\sim 10^8$ gpd capacities can be economical if designed for fixed rather than flexible product ratio and tailored to particular applications.

181 NUCLEAR DESALTING FOR AGRICULTURAL WATER. Hammond, R. Phillip (Oak Ridge National Lab., Tenn.). Nucleonics, 23: No. 9, 51-3; 55(Sept. 1965).

The role of nuclear desalination plants in solving the problem of agricultural water is discussed. Controlling factors, such as population growth, food requirements, and land and its use are discussed. The amount of water needed for food production is considered. Data on the cost of desalting are reviewed. It was concluded that, combined with improved agricultural techniques, nuclear desalting may add as little as 2.5 cents per day to the cost of man's food.

182 SEA-WATER DISTILLATION BY NUCLEAR POWER. Bethon, Henry E. Power, 104: No. 1, 82-3 (Jan. 1960).

A summary is presented on an economic study of a combined power-water desalination plant using a pressurized-water, heavy-water moderated and cooled reactor fueled with natural-uranium dioxide. The plant capacity would be 50 Mw(e) and 6 million gallons per day.

183 NUCLEAR ENERGY FOR WATER DESALINATION. Lewis, G. T. Power, 108: No. 12, 80-2(Dec. 1964).

The progress in a 50 million gallons per day nuclear desalination plant study is reviewed. Cost comparisons are made for five principal conversion processes, and fresh water production at a cost of 28 to 36 cents per 1000 gallons is predicted.

184 NUCLEAR PLANTS FOR WATER DESALTING GETS THOROUGH DISCUSSION AT ATOMIC INDUSTRIAL FORUM. Power Eng., 69: 61-2(Mar. 1965).

A survey is provided of reports on progress in the nuclear desalination program given at the Atomic Industrial Forum at San Francisco on Nov. 30, 1964. Major attention was paid to a large-scale nuclear desalting program that would provide regional water supply plants in the 1970's. Such plants would produce about 500 to 700 mgd (Mgal/day) of water and have an electrical output of over 100 Mw. Best economic potential for these plants seems to reside in the heavy water moderated organic cooled reactor (HWOCR) and the multi-stage flash distillation process (MSF). The first phase of this large-plant program has two objectives: to operate at least one intermediate-size prototype dual-purpose plant of about 50 mgad capacity; and to operate a prototype power-only HWOCR of about 1000 Mw capacity. These two objectives are scheduled to be achieved by 1970. In the second phase, a large dual-purpose prototype plant would employ a nuclear-energy source. General recommendations call for expanded research and development efforts in all phases of the program, and an increase of

$200 million in authorized expenditures through 1972. At present, the HWOCR concept is considered most promising for combination plants. Units up to 100,000 Mw are considered technically feasible at this time, and the reactor has the potential for low-energy costs in power-only or dual-purpose plants. It is recommended that large dual-purpose plants be developed as soon as possible, in an effort to achieve water costs in the range of 20 cents/1000 gal. Dual-purpose plants are envisioned that produce up to a billion gallons of water a day and thousands of megawatts of power.

185 FUTURE OF WATER DESALINATION. Galstaun, Lionel S.; Currier, Edwin L. Power Eng., 70: 36-42(May 1966).

Use of nuclear and other forms of energy in desalination of seawater by various processes is examined. While fossil fuel costs vary widely from one location to another, nuclear fuel cycle costs are essentially unaffected by location. They are often somewhat lower than fossil fuel costs and will drop further as the scale of operations in the nuclear industry expands. However, nuclear steam-supply systems tend to cost more than fossil-fired units. Consequently, the most economical energy source can be selected only after thorough evaluation of the various options. Factors that apply to such an analysis include the size of the heat supply and the local cost of fuel delivered to the facility. Experience has shown that nuclear energy will tend to be economical in the larger plants and fossil fuel in smaller ones. Nuclear fuel cycle costs are heavily dependent on the size of the nuclear power industry. Future lower cost will result from increased volume of production and improved technology. It is shown that a nuclear fuel cycle cost of 14¢/million BTU is competitive with oil-gas fuel at 23¢/million BTU. A dual-purpose plant generating about 600 Mw (net) power and 150 million gal/day of desalted water was considered.

186 DESALINIZATION OF WATER. Power Reactor Technol., 7: No. 2, 138-44(Spring 1964).

The design, development, economic aspects, and use of nuclear reactors for desalinization of sea water are reviewed. Results are summarized on reactor types used in studies of nine different electric generation-desalinization cases.

187 THE ECONOMICS OF COMBINED ELECTRIC POWER AND WATER DESALINATION PLANTS. Scarbrough, B. R. (Westinghouse Electric Corp., Philadelphia); Stinson, W. H.; Nordman, D. A. Proc. Amer. Power Conf., 27: 167-72(1965).

The economics of dual purpose plants are discussed, following a brief consideration of the technical feasibility of such plants.

188 NUCLEAR-POWERED DESALINATION OF SEA WATER FOR SOUTHERN ARIZONA. Post, Roy G.; Seale, Robert L. (Univ. of Arizona, Tucson). Trans. Am. Nucl. Soc., 7: 199-200(June 1964).

From American Nuclear Society 10th Annual Meeting, Philadelphia, June 1964.

A discussion concerning selection of the most economical method of providing desalinated water using currently demonstrated technologies is presented. It is concluded that the use of nuclear power to desalinate sea water appears to offer a feasible and potentially economic source of water for municipal areas and for agriculture where extensive transportation is not required.

189 ECONOMICS OF SMALL NUCLEAR ELECTRIC-DESALINATION PLANTS. Baer, Robert L.; Solberg, Donald E. (Hittman Associates, Inc., Baltimore). Trans. Am. Nucl. Soc., 8: 155-6(May 1965).

190 COMPARISON OF HIGH-TEMPERATURE AND LOW-TEMPERATURE REACTORS FOR USE IN DUAL-PURPOSE SEA-WATER EVAPORATOR AND ELECTRIC-POWER STATIONS. Van Winkle, R.; Ebel, R. A.; Winsbro, R. B. (Oak Ridge National Lab., Tenn.). Trans. Am. Nucl. Soc., 8: 156-7(May 1965).

191 USE OF LOW-TEMPERATURE FAST REACTORS FOR DESALINATION OR POWER. Carlsmith, R. S.; Hoskins, R. E. (Oak Ridge National Lab., Tenn.). Trans. Am. Nucl. Soc., 8: 157-8(May 1965).

192 WATER DESALTING SYSTEM STUDIES IN NUCLEAR ENGINEERING DESIGN CLASSES. Seale, Robert L. (Univ. of Arizona, Tucson). Trans. Amer. Nucl. Soc., 9: 210-11(June 1966).

193 A NOTE ON A NEW METHOD OF COST ALLOCATION FOR COMBINED POWER AND WATER DESALINATION PLANT. Barnea, Joseph (Resources and Transport Division, United Nations, New York). Water Resources Research, 1: No. 1, p.143-5(First Quarter 1965).

The cost allocation method described, which is for dual purposes or combined electricity water desalination plants, uses exclusively economic data. The method is based on the cost of power and water produced in single-purpose plants and on the application of the cost relationship for a given net output of water and power to the total annual cost of a combined plant.

PATENTS

194 NUCLEAR REACTOR POWER STATIONS. Thorn, James Doublas (to United Kingdom Atomic Energy Authority). British Patent 1,038,419. Aug. 10, 1966. Filed Aug. 27, 1964.

A nuclear power station design is presented using a steam-powered system for circulating gas coolant. The steam is received at intermediate pressure from a reheat line and exhausted to a desalination plant.

195 DISTILLATION OF SEA WATER EMPLOYING NUCLEAR ENERGY. Pedrick, Arthur Paul. British Patent 1,042,541. Sept. 14, 1966. Filed Apr. 12, 1965.

A method is described for distillation of sea water by pumping a stream of sea water over the outer surface of a nuclear reactor, which is mounted for rotation and provided with screw blades so that the flow of sea water maintains the reactor in rotation. The heat energy from the reactor is transferred to the sea water by conduction causing the sea water to boil. The steam so produced is guided to a condenser. During the rotation of the reactor, the scraper blades remove deposits of salt resulting from the boiling of the sea water. The reactor is described for particular application to "floating fields" described in British Patent 1,038,320 and which would be maintained in an area, not necessarily far from the coastline, but at a sufficient distance not to provide any form of radiation hazard to inhabitants of the local area.

MISCELLANEOUS

196 THE ROLE OF NUCLEAR ENERGY IN WATER CONVERSION BY DISTILLATION. Hainsworth, W. R.; Brice, D. B.; Dusbabek, M. R. pp. 398-407 of "Proceedings of a Symposium on Saline Water Conversion," Nov. 4–6, 1957. Washington, D. C., National Academy of Sciences-National Research Council. Publication 568 (1958).

A study of the combination of reactors and distillation processes which will produce the lowest cost water is presented with emphasis on large-scale aspects of desalination. Graphite, heavy and light water heterogeneous reactors using natural or slightly enriched, aluminum-clad uranium fuel elements, combined with multiple-effect flash or evaporation distillation plants are studied. The best combination of systems is determined to be a heavy water-moderated and cooled reactor combined with a seven-page long-tube-vertical multiple-effect evaporator. Plant costs and operating expenses and their effect on the cost of water produced are summarized.

197 A STUDY OF THE FEASIBILITY OF USING AN UNDERGROUND NUCLEAR EXPLOSION AS A SOURCE OF HEAT ENERGY FOR THE DISTILLATION OF SEA WATER. Fatt, I. Univ. of California (Berkeley), Sea Water Conversion Program, Series No. 75, Issue No. 17, Sept. 24, 1959. 31p.

The possibility of using the heat energy released in underground nuclear explosions for the desalination of sea water is examined. The conditions that may exist in systems where sea water is pumped into the heated zone created by an explosion and the heated water returned to the surface and there vaporized to give steam and solids

are investigated. The economics of such systems are roughly estimated from AEC proposed charges for nuclear bombs and the costs for hot sea water delivered to the surface are found to be high.

198 SALINE WATER DEMINERALIZATION AND NUCLEAR ENERGY IN THE CALIFORNIA WATER PLAN. Koch, Albert A. California. Department of Water Resources. Division of Resources Planning. Bulletin 93. December 1960.

Described are the various phases of the problems of nuclear energy and saline water conversion, as they apply to the water problems of the state of California. The present status of saline water conversion and its future possibilities indicate that it will cost at least two to five times more than development of natural water resources. The possible application of nuclear energy to sea water conversion and the production of electrical and mechanical power is discussed and it is indicated that nuclear energy will have a marked effect on the future development of the California Water Plan.

199 SEA WATER CONVERSION BY THE MULTISTAGE FLASH EVAPORATION METHOD. Brice, D. B.; Townsend, C. R. pp.147-55 of SALINE WATER CONVERSION, ADVANCES IN CHEMISTRY SERIES NO. 27, American Chemical Society, Washington, D. C. 1960. $5.85.

The economics of fresh water production based on the multistage flash evaporation of sea water is discussed for a single-purpose, 50 million gallon per day plant. The steam generator employed is a 370 Mw(t) pressurized light-water reactor. Based on present technology, the water costs are estimated at 38 to 42 cents per thousand gallons, with future costs predicted to be 24 to 31 cents per thousand gallons within the next decade.

200 NUCLEAR APPLICATIONS TO SALINE WATER CONVERSION. ECONOMIC IMPLICATIONS. A PANEL DISCUSSION. pp.1-16 of "Proceedings of the Tenth Anniversary Conference of the Atomic Industrial Forum." New York, Atomic Industrial Forum, 1964.

The results of studies on the economics of nuclear desalination plants, particularly plants also producing electricity, are summarized, together with associated technological efforts. Cost estimates are given, including comparisons of conventional and nuclear systems.

201 SEA-WATER CONVERSION USING SMALL NUCLEAR HEAT SOURCE. Scanlon, T. R.; Schoenbrunn, A. G.; Minners, W. ASME-Paper 64-WA/NE-8 for meeting Nov. 29–Dec. 4, 1964. 7p.

A 21 Mw(t) reactor is studied for use in operating a multieffect, multistage flash distillation plant for the desalination of seawater. The nuclear plant is basically an upgraded research reactor using UO_2 pressure-tube fuel elements, and the new distillation cycle operates at higher efficiencies than present day multistage flash distillation cycles.

202 USE OF NUCLEAR POWER FOR THE PRODUCTION OF FRESH WATER FROM SALT WATER. HEARING BEFORE THE JOINT COMMITTEE ON ATOMIC ENERGY, CONGRESS OF THE UNITED STATES. Eighty-Eighth Congress, Second Session. August 18, 1964. $0.40(GPO).

Included in the Hearing are a year-by-year breakdown of funds appropriated to the Office of Saline Water, a compilation of pilot plants built and operated by the OSW, a list of contractors performing work, approximate cost of the contract, and the scope of work being performed, and a list of AEC contractors engaged in desalination work, the rate of funding, and the nature of the work they are doing. Appendices include a summary of a report by the Office of Science and Technology on nuclear power and water desalting, a report by the IAEA on desalination using conventional and nuclear energy, papers presented by AEC commissioner James T. Ramey at the Geneva Conference and the IAEA Panel Meeting on Nuclear Desalination, the report to the President on a "Program for Advancing Desalting Technology," and papers presented by the U.S.S.R. Delegation during its July 1964 visit to the United States.

203 LARGE NUCLEAR-POWERED SEA WATER REVERSE OSMOSIS PLANTS. Keilin, B.; Watson, E. R. (Aerojet General Corp.). 10p. Delivered at the 149th National Meeting, American Chemical Society, Detroit, Michigan, April 5, 1965.

The advantages of the reverse osmosis process are examined for the large scale purification of sea and brackish waters. Energy requirements and capital costs are compared for reverse osmosis and distillation plants, and their economy of operation using an 8300 MW(t) heavy water moderated, organic-cooled reactor as the heat source is examined. It is shown that dual purpose reverse osmosis plants can yield as much saleable electric power and produce a considerably greater quantity of water than can the distillation system under optimum conditions. In addition, the unit cost of water will be less for the reverse osmosis process.

204 OUTLOOK FOR THE USE OF NUCLEAR ENERGY FOR THE PRODUCTION OF HEAT AT LOW TEMPERATURE. Baldetti, S.; Biondi, L.; Cerullo, N.; Di Menza, R.; Guerrini, B.; Lazzarino, L.; Pierazzi, L.; Vaudo, A. pp 223-51 of Giornate dell'Energia Nucleare 1964. Milan, Federazione delle Associazioni Scientifiche e Tecniche, 1965. (In Italian).

Vapor at relatively low temperatures and pressures can be used in industrial plants (principally chemical), for domestic heating, and for the desalination of seawater. The utilization of nuclear power plants for the production of vapor at low temperature at a competitive cost was examined. In the power area and the vapor characteristics that best satisfy the utilizations discussed, organic-cooled reactors seemed of special interest. After a preliminary examination of the most promising lines of development of an organic reactor for production of heat at low temperature, preliminary results in a design study of this type of reactor are presented.

205 APPLICATION OF NUCLEAR ENERGY FOR DESALINATION. Dall'Asta, G.; Bortone, C. pp 253-71 of Giornate dell'Energia Nucleare 1964. Milan, Federazione delle Associazioni Scientifiche e Tecniche, 1965. (In Italian).

Needs for desalination, the systems used, the proposed utilization of nuclear reactors for this purpose, and the principles of the multi-flash evaporation system are reviewed, and the coupling of reactors and desalinators is discussed. In the coupling of nuclear reactors and desalinators various problems are presented. The use of a reactor for water alone or for the simultaneous production of electrical energy is considered. The conditions under which a nuclear reactor would be more economical as a heat source than a conventional fuel power plant are considered. In the case of electricity production the use of controlled pressure turbines is compared with the use of condensation turbines. The advantages of reactors producing vapor at high temperatures or low temperatures are considered.

206 SOME ALTERNATES FOR THE UTILIZATION OF ORGANIC LIQUID REACTORS FOR DESALINATION OF SALT WATER. Di Menze, R.; Pittori, S.; Pierazzi, L.; Valant, P. pp 273-84 of Giornate dell'Energia Nucleare 1964. Milan, Federazione delle Associazioni Scientifiche e Tecniche, 1965. (In Italian).

An economic comparison was made of water and organic nuclear reactors for the simultaneous production of electrical energy and vapor and of organic reactors for vapor production and of water reactors for the simultaneous production of electrical energy and vapor. The water reactors considered were the PWR and the BWR. The results showed that the dual-purpose organic reactors could not be competitive with the water reactors for powers of the order of 150 MW(t). At 1700 MW(t) however the two reactors would be competitive. The unit cost of thermal energy at 1500 MW(t) was decidedly higher for the vapor-producing organic reactor. At powers below 150 MW(t), however, the situation was reversed.

207 NUCLEAR DESALINATION ABROAD: THE ISRAEL PROJECT. Bush, Philip D. (Kaiser Engineers, Oakland, Calif.). pp 148-62 of Proceedings of the 1965

Conference, Atomic Industrial Forum, Inc., Washington, D. C. McCluskey, Robert J. (ed.). New York, Atomic Industrial Forum, 1966.

The reference design selected in a joint United States–Israel study of a dual-purpose power-desalination plant is described. The plant complex consists of a light water reactor, a back pressure turbine, and a multi-stage flash evaporator with capacities of 200 MW(e) and 100 million gallons of water per day. Engineering and economic aspects of the plant are discussed and a proposed development schedule is presented.

208 OPRESNENIE SOLENYKH VOD. METOD DISTILLYATSII S ISPOL'ZOVANIEM TEPLA YADERNYKH REACTOROV. (Desalination of Salty Waters. Methods of Distillation Using Nuclear Reactor Heat). Mal'tsev, E. D. Moscow, Atomizdat, 1965. 92p.

A brief review is given on various methods for desalination of saline waters. The use of hydrophobic coolants, intensification heat exchange by film formation by means of stationary column packing, removal of scum-forming salts by sorption on resins, followed by regeneration of the resins from the evaporators are described. The performance of nuclear reactors for desalination and production of electricity is also discussed.

209 DEVELOPMENT, GROWTH, AND STATE OF THE ATOMIC ENERGY INDUSTRY. HEARINGS BEFORE THE JOINT COMMITTEE ON ATOMIC ENERGY, CONGRESS OF THE UNITED STATES, EIGHTY-NINTH CONGRESS, FIRST SESSION, AUGUST 10, 11, AND SEPTEMBER 8, 1965. Washington, D. C., Joint Committee on Atomic Energy, 1965. 624p. GPO $2.00.

Topics covered include: AID financing of reactors, air pollution, breeder reactors, coal use, competition in nuclear industry, cost of coal-fired power, costs of nuclear power, desalination, education in the nuclear field, fast breeder reactors, fast reactor fuel tests, foreign sales, fuel cycle, fuel cycle guarantees, fuel inventory cost, reprocessing fuels, gas-cooled breeder reactors, nuclear power growth, heavy water organic reactors, design improvements in nonbreeder reactors, nuclear ships, indemnity legislation, isotope uses in industry, licensing, Long Island reactor proposal, maritime reactors, national laboratories, oceanographic programs, nuclear fuel cycles, operating contract award policy, plutonium, the plutonium recycle reactor, fabrication of pressure vessels, nuclear weapon proliferation, submarine propulsion by radioisotopes, regulatory jurisdiction, reliability of nuclear power, safeguards agreements and inspection, seed blanket reactor, siting, sodium component development, sodium pump test facility, steam-cooled breeder reactors, supercritical reactors, superheat reactors, toll enrichment, and uranium conversion to hexafluoride.

210 SALINE WATER CONVERSION REPORT FOR 1964. (Office of Saline Water, Washington, D. C.). 304p. GPO $2.00.

A detailed summary is presented of the 1964 desalting operations of the Department of the Interior. Research, processes, and demonstration plants are covered.

211 FRESH WATER FROM THE SEA. Proceedings of the International Symposium held in Milan, April 20–21, 1964. Gireili, Alberto (ed.). New York, Pergamon Press, 1965. 200p. $9.00. (CONF-640415).

Eight papers presented at the symposium are given. Topics covered include: Application of ion exchange for conversion of saline water into fresh water, sea and brackish water desalting in Japan, developments in obtaining fresh water from seawater in Germany, British activities in desalination development and research, desalination research in Italy, the state of desalination research in Israel, evolution of the distillation process for seawater conversion, and the role of the United Nations Department of Economic and Social Affairs in the field of water desalination.

212 LARGE NUCLEAR-POWERED SEA WATER REVERSE OSMOSIS PLANTS. Keilin, B.; Watson, E. R. 10p. (CONF-650401-8). Gmelin, AED-CONF-65-041-26.

From American Chemical Society, Detroit.

It is pointed out that reverse osmosis can be used in conjunction with a nuclear reactor to yield at least as much electrical power and, at the same time, produce a considerably greater quantity of water in a desalting plant than the distillation system under optimum conditions.

213 COST DETERMINATION AND COMPARISON OF NUCLEAR AND FOSSIL FUELED DUAL-PURPOSE POWER AND DESALINATION PLANTS. Fruth, Hans. 19p. (CONF-651005-4). ORAU. Gmelin, AED-CONF-65-276-8.

From 1st International Symposium on Water Desalination, Washington, D. C.

The general conditions and reasons for which lower fresh water costs may be expected with the nuclear-dual purpose plants than fossil fueled plants are presented. A determination method is developed by means of the energy concept to allow the accomplishment of an equitable cost breakdown in a dual-purpose plant based on the design data of the plant itself, independent of cost comparisons with reference plants or market conditions. The economics of nuclear-fueled single-purpose desalting plants is discussed.

214 REACTOR STEAM CYCLES FOR DESALINATION. Chambers, S.; Hitchcock, A. 10p. (CONF-651005-5). ORAU.

From 1st International Symposium on Water Desalination, Washington, D. C.

The principles involved in the optimization of nuclear dual-purpose power-water plants are discussed assuming only modest advances in reactor and flash distillation plant technology. Comparisons between reactor types as sources of heat and economic considerations are examined.

215 AN ANALYSIS OF THE DYNAMIC BEHAVIOR OF DUAL PURPOSE POWER/DESALINATION NUCLEAR PLANTS. Saphier, D.; Wolberg, J. R.; Yiftah, S. 19p. (CONF-651005-7). ORAU.

From 1st International Symposium on Water Desalination, Washington, D. C.

A model of a dual purpose power/desalination nuclear plant is described and used to simulate operation for a variety of control systems and disturbances in the operating conditions. A comparison of the dynamic behavior of the plant to nuclear single purpose plants indicates the model is in working order.

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